



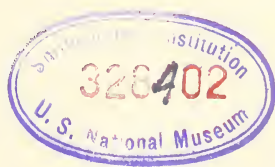
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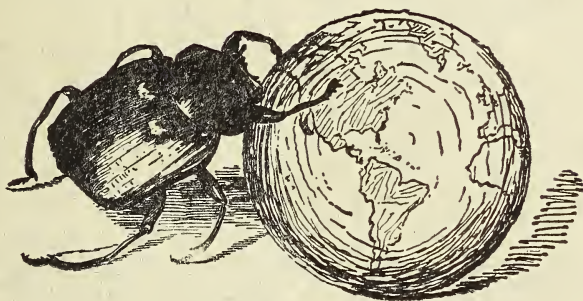
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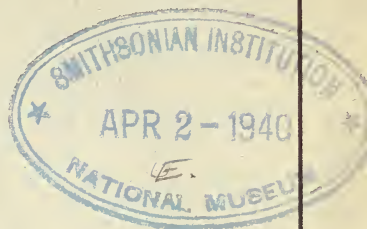
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No. 1

AN INTRODUCTORY STUDY OF POLISTES IN THE UNITED STATES AND CANADA WITH DE- SCRIPTIONS OF SOME NEW NORTH AND SOUTH AMERICAN FORMS (HYMENOPTERA; VESPIDÆ)

BY JOSEPH C. BEQUAERT

MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASS.

Over ten thousand wasps have now been examined for the forthcoming revision of North American *Polistes*. Although I hope to study as many more before completing the work, the time has come to put on record some of the results, for the benefit of others. Moreover, the manuscript names distributed to various collections should be validated, according to the rules, without further delay.

In the United States I recognize four "structural species," only one of these entering Canada. Each species is represented by several color forms, or "varieties." The males of the four species are readily told apart; but most of the differentiating characters of the females or workers are subtle and difficult to put in words. They become gradually more apparent as one examines more specimens. This should be kept in mind when using the subjoined key. In all social species of *Polistes* with which I am acquainted, the workers (when present) and fertile females (or queens) are alike, both in structure and color and often also in size. It is generally assumed that the smaller females, sometimes found in the colony, are workers. Moreover, even unmated females (or workers) may occasionally lay eggs, which develop by parthenogenesis into male wasps.

APR 2 1940

KEY TO SPECIES

1. Body slender. Abdomen elongate-fusiform, widest about mid-length, more or less compressed apically; first tergite slightly convex in profile and gradually sloping onto the base, seen from above slightly longer than wide at apex. Second sternite little convex, not bulging in profile. Apical sternite of male without medio-basal tubercle..... 2.
- Body thickset. Abdomen ovate-fusiform, widest before middle, more or less depressed apically; first tergite strongly convex in profile and rather abruptly sloping onto the base, seen from above as wide at apex as long or wider. Second sternite strongly convex, bulging in profile. Mesopleura with microscopic sculpture only..... 3.
2. Propodeum distinctly striate transversely throughout. Mesopleura with many large punctures scattered in the microscopic sculpture. Collar of pronotum high and sharp, forming raised humeral angles. Clypeus of female touching the eyes over a distance at most half the length of the oculo-malar space. Clypeus of male subquadrate and flattened, contiguous to the eyes..... *P. canadensis*.
- Propodeum very finely striate, except in the median groove. Mesopleura with the microscopic sculpture only, without larger punctures. Collar of pronotum low and blunt, weakly projecting at the humeri. Clypeus of female touching the eyes over a distance about equal to the length of the oculo-malar space. Clypeus of male irregularly heptagonal and slightly convex, broadly contiguous to the eyes..... *P. exclamans*.
3. Propodeum coarsely striate throughout, with some 20 to 22 strong transverse ridges. Mesopleura often with at least traces of a prepectal suture running obliquely upward on the anterior convexity. Clypeus of female touching the eyes over a distance at most half the length of the oculo-malar space. Clypeus of male subquadrate, with the anterior margin straight or very slightly convex, the sides always widely separated from the eyes. Apical sternite of male without medio-basal tubercle *P. major*.
- Propodeum finely or moderately striate, usually more strongly in the median groove, the striae numerous but not ridge-like. Mesopleura never with a trace of a prepectal suture, the anterior convexity smooth. Clypeus of female touching the eyes over a distance equal to one-half or more of the length of the oculo-malar space. Clypeus of male irregularly hexagonal, more or less broadly separated from the eyes (often scarcely so). Apical sternite of male with a small but distinct medio-basal tubercle *P. fuscatus*.

Two names proposed for North American *Polistes* remain a puzzle. In 1872 (Trans. Amer. Ent. Soc., IV, pp. 245-246) Cresson described *P. perplexus* and *P. generosus*, both based on males only, from Texas. I have studied his types at the Philadelphia Academy of Sciences, on several occasions. There can

be no doubt that *P. generosus* is only a variant of *P. perplexus*, as Cresson surmised, and it should be treated as a synonym of the latter. These males agree in every important structural character with *P. fuscatus* and at one time I regarded them as aberrant males of typical *fuscatus*. They are unusual, however, in being larger and especially stouter than the regular males of even var. *metricus* and var. *rubiginosus*. I have in my collection 12 males from Texas (some without more definite locality; others from College Station, Shiloh and Brazos Co.), 1 male from Kentucky (Woodford) and 1 male from Indiana (Bloomington), which cannot be separated from *perplexus* and *generosus*. I have also 6 females from Texas (some without more definite locality; others from Austin and College Station) and 1 female from Indiana (without more definite locality), which appear to be the other sex of Cresson's *perplexus* and *generosus*. These females also are unusually large and stout for forms of *P. fuscatus*. In both sexes these supposed *perplexus* wasps give the impression of being more powerful insects, with very strong striation of the propodeum, the head more swollen (particularly the outer orbits) and the legs and antennæ slightly shorter and stouter. I have been unable, however, to find more tangible structural differences from *P. fuscatus*. I should have attached little importance to the more powerful build of these supposed *perplexus*, were it not for the possibility that they may represent a distinct species, living as a social parasite in the colonies of either var. *metricus* or var. *rubiginosus*. This parasitic species may have been derived so recently from its social ancestor (presumably some form of *P. fuscatus*), that it has as yet developed no cogent structural differences. Several Palearctic species of *Polistes* are now known to be true social parasites (W. Weyrauch, 1937, Zool. Jahrb., Abt. Syst. Tiere, LXX, pp. 243-290) and I have suggested recently that some of the Ethiopian species have similar parasitic habits (J. Bequaert, 1938, Rev. Zool. Bot. Afric., XXXI, p. 130). No doubt parasitic *Polistes* will also be discovered in the New World. Carefully controlled observations in the field alone will enable one to decide whether or not my surmise is correct in the case of *P. perplexus*. If it is a true social parasite, the species will consist only of males and impregnated females. The females will build no nests nor form colonies of their own. Instead, they will

seek out existing colonies of some social *Polistes*, in which to deposit their eggs. The larvæ hatching from these alien eggs will then be raised by the original and rightful builders and inhabitants of the nest.

The wasps recorded as *P. perplexus*, from Bermuda, by W. F. Kirby, Verrill and Ogilvie, are *P. fuscatus* var. *nestor* (Fabricius).

Vespa carolina Linnaeus (1767, Syst. Nat. 12th Ed., I, pt. 2, p. 948), from Carolina, was undoubtedly based upon a North American *Polistes*, as I have pointed out before (1931, Entomologica Americana, XII, p. 108). The type is so poorly preserved and the description so inadequate, that it is impossible to decide whether it was *P. canadensis* var. *annularis* or one of the forms of *P. fuscatus* (possibly a male of *P. fuscatus* var. *rubiginosus*). For this reason, it seems preferable to drop the name altogether.

The following names have been applied erroneously to *Polistes* of our territory.

P. crinitus (Felton).—This is a strictly West Indian wasp, structurally distinct from the four North American species. Its nearest relative in North America is *P. exclamans*, which has sometimes been mistaken for it.

P. minor Palisot de Beauvois, described originally from Santo Domingo, is also strictly West Indian in my opinion. The wasps frequently called *P. minor* in the United States are usually *P. fuscatus* var. *hunteri*, sometimes *P. exclamans*.

P. carnifex (Fabricius) is occasionally confused with *P. major*. True *carnifex*, as characterized in 1936, Rev. de Entomologia, VI, pp. 376–383, I have never seen from the United States or the West Indies.

P. instabilis H. de Saussure was recorded by F. Smith (1857) from East Florida, Mount Pleasant (Ohio) and New York. True *instabilis*, however, is a Central American wasp (See under *P. exclamans*).

In the enumeration of species and varieties I have inserted the published names which I regard as synonyms, without further discussing the matter. The opportunity has been used to publish the descriptions of some new color varieties from the West Indies, Central and South America.

In brief, only three forms of *Polistes fuscatus* are known with

certainty from Canada: var. *pallipes* (Quebec and Ontario), var. *connectens* (Alberta) and var. *aurifer* (British Columbia).—In the United States the following occur: *P. canadensis*, typical, *P. canadensis* var. *annularis*, *P. canadensis* var. *comanchus*, *P. canadensis* var. *kaibabensis*, *P. canadensis* var. *navajoe*, *P. exclamans*, typical, *P. exclamans* var. *louisianus*, *P. major*, typical, *P. major* var. *palmarum*, *P. major* var. *castaneicolor*, *P. major* var. *bakeri*, *P. fuscatus*, typical, *P. fuscatus* var. *anaheimensis*, *P. fuscatus* var. *apachus*, *P. fuscatus* var. *aurifer*, *P. fuscatus* var. *centralis*, *P. fuscatus* var. *bellicosus*, *P. fuscatus* var. *connectens*, *P. fuscatus* var. *flavus*, *P. fuscatus* var. *hunteri*, *P. fuscatus* var. *metricus*, *P. fuscatus* var. *montanus*, *P. fuscatus* var. *nestor*, *P. fuscatus* var. *pallipes*, *P. fuscatus* var. *rubiginosus*, *P. fuscatus* var. *utahensis*, and *P. fuscatus* var. *variatus*.

The North American *Polistes*, like those of other parts of the world, are quite variable in the extent, arrangement and shade of color markings. The extreme case is perhaps that of *P. fuscatus*, in which color seems to run riot and to defy any attempt at rational analysis. The true meaning of these variations as yet escapes us, although a theory is by no means lacking. What we really should know, before attempting to build up theories, is the genetic background of the color differences, whether or not and to what extent they are hereditary in a given population and how they behave when crossed; also to what extent they may be influenced by environmental conditions (nature and amount of food, climate, resistance to disease, natural selection by predators, etc.). It would seem that only experiments can furnish decisive answers to these questions. Meanwhile, from observation alone, the several color variations of one structural species appear to be of unequal value, hence probably due to different causes. At least four types of variants may be recognized.

(1) Some variations may be purely individual or fluctuating and probably due entirely to environmental conditions during the ontogeny. It is frequently difficult to find two individuals colored alike in every detail, even within the same population or among the offspring of a single queen. The differences among the inmates of one nest may, however, be explained to some extent by the frequent association of two or more queens in the found-

ing of a new colony (pleometrosis: See J. Bequaert, 1923, Bull. Brooklyn Ent. Soc., XVIII, pp. 73-80).

(2) Sometimes two or more variants occur in the same locality, which, though quite distinct in the extreme or "typical" individuals, yet are connected by many intergrades. In most cases the intergrades are probably hybrids. In the northeastern United States, for instance, one finds three forms of *P. fuscatus*:¹ (a) typical *fuscatus* is relatively uncommon in the central part of this area, from southern Massachusetts to West Virginia; (b) the var. *nestor* is common from southern Pennsylvania to South Carolina and eastern Texas, with an occasional specimen in New Jersey and on Long Island; (c) the var. *pallipes* is characteristic of southern Canada, New England, and northern New York, with a few stragglers farther south in the Alleghany Mountains. From the distribution and relative scarcity, it would seem that typical *fuscatus* (as described by Fabricius) may not be a distinct "race" at all, but merely a name or label for hybrids between *pallipes* and *nestor*, where the ranges of these two forms overlap.

(3) Two or more variants of a species may occur over much the same territory, yet be so well defined that intergrades are hardly ever met with. Thus in the mid-western States, particularly in the drainage of the Mississippi, one finds commonly in one locality three varieties of *P. fuscatus*, viz., *variatus*, *metricus* and *rubiginosus*. Each by itself is more or less variable, but specimens that might be regarded as connecting two of them are exceedingly rare or lacking. Their scarcity rather indicates that, in this case, such intermediate specimens are merely extreme individual variants, not true intergrades or hybrids. Perhaps we are dealing here with ecological, physiological or even behavioristic races. Phil Rau has shown, for instance, that in the region of St. Louis, Missouri, three color forms of *Polistes fuscatus* nest in different types of environment (1931, Bull. Brooklyn Ent. Soc., XXVI, pp. 111-116). The "isolation" of such races may be enhanced by the social behavior, brothers and sisters tending to mate on or near the nest, while young queens often return to their mother's nesting site. In any case, the correlation be-

¹ As is the rule in *P. fuscatus*, these three forms are recognizable in the female and worker only. The males of this species rarely show the color differences on which the several varieties are based.

tween such extra-morphological differences and the visible color characters can only be fortuitous.²

(4) Finally, in a few cases the variants agree fairly well with the classic concept of "geographical races" or "subspecies." They are sharply defined, apparently without intergrades to other forms, and inhabit a limited district to the exclusion of other color variants of the same species. There are few clear-cut cases of this type among the variants of *P. fuscatus*, the nearest approach being perhaps the two forms of the Pacific Coast, var. *aurifer* and var. *anaheimensis*, although the areas of both overlap to some extent. Better examples are the variants of *P. canadensis*: var. *annularis* (in the southeastern States), var. *kaibabensis* (in the Grand Canyon of the Colorado River), var. *navajoe* (in the Upper Sonoran of Arizona), and var. *comanchus* (in the Upper Sonoran of southwestern Texas).

A corollary to the differentiation of "races" on a geographical basis is the convergence in color pattern, or homeochromy, sometimes exhibited by several structural species of *Polistes*, other wasps or other insects in general, occurring in the same area. Illustrations of this are few in the North American *Polistes*. There is, however, a decided superficial resemblance between *P. fuscatus* var. *metricus* and *P. canadensis* var. *annularis*, in the southeastern States; between typical *P. exclamans* and *P. fuscatus* var. *bellicosus*, in the southeastern States; and between *P. canadensis* var. *navajoe* and *Mischocyttarus flavitarsis* var. *navajoe* in Arizona. Whether or not these are cases of "protective coloration," I shall not attempt to discuss.

Polistes canadensis (Linnaeus)

The most widely distributed American species of the genus, although it does not reach Canada. Linnaeus was evidently misled as to the locality of his specimens, like in so many other cases. It extends from south of the Great Lakes and Utah to northern Patagonia. It is, however, unknown in California and Chile. In this vast territory it has produced several color forms, thirteen of which have been named thus far. Four more are

² A similar fortuitous correlation exists, for instance, between the egg-pattern and the physiological differences of the several races of *Anopheles maculipennis*.

described below. Of these seventeen varieties, five only occur in the United States.

KEY TO NEARCTIC COLOR FORMS OF *P. CANADENSIS*

1. Abdomen either without yellow markings, or the first tergite only with an apical yellow margin 2.
 Abdomen more extensively yellow or orange-yellow, particularly over the third and succeeding segments, which are often almost entirely of that color 3.
2. Body fairly uniformly light to dark mahogany-brown, the head and thorax sometimes lighter than the abdomen. Yellow apical margin of first tergite more or less distinct, sometimes lacking. Wings purplish-black, sometimes with a russet tinge, which becomes gradually more pronounced apically, the veins and stigma either black or russet according to the color of the surrounding membrane typical *canadensis*.
 Head and thorax dark mahogany-brown, sometimes blotched with black; abdomen usually jet-black, blotched with mahogany-brown on the first segment and occasionally elsewhere. First tergite always with a distinct yellow apical margin. Wings uniformly deep purplish-black, the veins and stigma black var. *annularis*.
3. Head, thorax, legs, and abdomen light reddish-brown, with extensive yellow markings on head and abdomen. Wings ferruginous, very slightly purplish; costal area, veins and stigma russet var. *kaibabensis*.
 Ground color of head, thorax, and legs black 4.
4. Head black, extensively marked with orange-yellow; thorax black, only narrow margins of pronotum and tegulae orange; abdomen mostly orange-yellow, elsewhere ferruginous, only the base of first tergite black. Wings ferruginous, slightly purplish, the veins and stigma russet.
 var. *comanchus*.
 Head black, extensively marked with yellow; thorax black, the pronotum partly, tegulae and scutellum orange-yellow; abdomen mostly yellow, elsewhere black, the first and second tergites somewhat reddish at the limits of black and yellow areas. Wings strongly purplish-black, only extreme base and costal area somewhat russet, the veins and stigma black var. *navajoe*.

1. *P. canadensis*, typical.—Distributed over most of the Neotropical Region. I have seen it from Mexico, Guatemala, Honduras (Rep.), Colombia, Venezuela, British Guiana, Trinidad, Brazil, Peru, Bolivia and Paraguay. It barely enters the United States at the southern border of Arizona. Two females taken at Nogales by Dr. J. C. Bradley are exactly like a series I have received from Vera Cruz and Sonora (Bakachaka; Estrella District, Alamos).

2. *P. canadensis* var. *amazonicus* W. A. Schulz.—Known from Brazil, British Guiana, Panama, Ecuador and British Honduras.

3. *P. canadensis* var. *annularis* (Linnæus).—*Vespa cincta* Drury (1773), *Vespa virginienensis* "Drury" Dalla Torre (1894) and *Polistes annulata* Moebius (1856) are synonyms. The most widely distributed form of the species in the United States. I have seen it from Connecticut (New Haven), southern New York (Ft. Montgomery; Hillburn; Orient, Long Island; Ramapo Mts.; also taken many years ago on Staten Island by Mr. Wm. T. Davis), New Jersey (Paterson; Jamesburg; Cape May), Pennsylvania (Pittsburgh), Maryland, Virginia, District of Columbia, West Virginia, southern Ohio (Hocking Co.; Sugar Grove, Ross Co.; Clifton, Greene Co.), southern Indiana, southern Illinois (New Columbia; Fort Chartres State Pk.), southern Iowa (Page Co.), Missouri, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Oklahoma, eastern Kansas (Blue Rapids), and eastern Texas (as far west as Bexar Co.). It will be found also in Delaware, Arkansas, and southeastern Nebraska. It is not known from south of 42°, west of the 100th Meridian, or outside the United States.

4. *P. canadensis* var. *buyssoni* Brèthes, 1909, An. Mus. Nac. Buenos Aires, (3) X, p. 456.—Syn.: *Polistes cavapyta* var. *thoracica* R. du Buysson, 1906, Ent. Medd., Copenhagen, III, p. 19. Not *Polistes thoracicus* Fox, 1898. This form is common in certain parts of Argentina.

5. *P. canadensis* var. *cavapyta* de Saussure.—*Polistes opalinus* de Saussure appears to be a synonym. A form of northern Argentina, southern Brazil, Uruguay and Paraguay.

6. *P. canadensis* var. *cinctus* Lepeletier.—*Vespa* (*Polistes*) *dominica* Vallot (1802) may be the same. A form peculiar to the lesser Antilles, where it is known from Martinique, St. Vincent, St. Kitts, the Grenadines and Barbadoes. It was also introduced into Montserrat and St. Lucia, where it appears to have taken a foothold. This is one of the smaller forms of the species (fore wing 14 to 17 mm. long).

7. *P. canadensis* var. *comanchus* de Saussure.—This form is characteristic of the Upper Sonoran life zone of southwestern

Texas (Brewster Co.; Jeff Davis Co.). I have seen it also from the Sierra de los Burros, State of Coahuilla, Mexico.

8. *P. canadensis* var. *erythrocephalus* Latreille, 1817, in Humboldt and Bonpland, Recueil d'Observations de Zool. Anat. Comp., II, p. 96, Pl. XXXVIII, fig. 3 (♀; South America).—The description and figure leave no doubt as to the identity of this form. It is characterized by the jet-black thorax and abdomen, the ferruginous head and antennæ (except for the median black ring), the black legs with ferruginous or orange knees and tarsi, and the bluish-black wings. At one time I distributed it as a new variety with a name derived from Costa Rica. Dalla Torre overlooked Latreille's name. The var. *erythrocephalus* is found in Nicaragua (Sioux Plantation, Rio Grande; Eden), Costa Rica (common), Panama (common), parts of Colombia (Dept. Santander, Dept. Boyacá and Dept. Tolima), and southern Brazil (Sete Lagoas, State of Minas Geraes). It is sometimes called *P. rufidens* in collections, but de Saussure's *rufidens* is structurally distinct from *P. canadensis*.

9. *P. canadensis* var. *ferreri* H. de Saussure.—Uruguay and northern Argentina.

10. *P. canadensis* var. *kaibabensis* Hayward, 1932, Proc. Utah Ac. Sci., IX, p. 89, Pl. IX, figs. 4, 12, 13 and 16. This interesting form is known only from the rim of the Grand Canyon of the Colorado River, Arizona, where it is common.

11. *P. canadensis* var. *lanio* Fabricius.—I have seen this from Brazil and Peru.

12. *P. canadensis* var. (or subsp.) **mexicanus**, new.

Female and Worker.—Body and legs bright reddish-brown, only the sutures of the thorax, a median line over anterior half of mesonotum and a narrow stripe in concavity of propodeum (widened below), black; middle of flagellum infuscated; the following markings are yellow: apical fasciæ on all tergites and second to last sternites (reduced on first and second, very extensive on the others and more or less divided on each side by a wavy reddish line or sometimes emarginate) and the knees and hind tarsi more or less. Wings very strongly infuscate, purplish-black.

Male.—Colored exactly like the female.

Holotype: Cuernavaca, State of Morelos, MEXICO, female (G. Lassman).—*Allotype*: Cuernavaca, male (A. L. Melander).—*Paratypes*: Cuernavaca, four females and two males; Teotihuacan,

State of Mexico, MEXICO, two females (S. E. Jones); Valerio, Trujano, State of Oaxaca, MEXICO, two females (M. Embury and A. Mead).—Holotype, allotype and several paratypes at Museum of Comparative Zoölogy, Cambridge, Mass.; two paratypes in Dr. R. M. Bohart's collection.

This form is nearest to the Argentinian varieties *ferreri*, *cavapyta* and *buyssoni*, but the abdomen is more extensively marked with yellow than in *ferreri*, while the yellow markings of head and thorax of *cavapyta* and *buyssoni* are lacking. In the North American fauna it is nearest var. *kaibabensis* and var. *wheeleri*, differing from the former in the color of the wings and from both in the reddish-brown head.

13. *P. canadensis* var. *navajoe* Cresson.—A common form in Arizona, also found in northern Mexico: south of Nogales, State of Sonora (P. P. Calvert); Escuinapa, State of Sinaloa (J. H. Batty). Apparently characteristic of the Upper Sonoran life zone.

14. *P. canadensis* var. *panamensis* Holmgren.—Common in Panama and parts of Colombia (Santa Marta district).

15. *P. canadensis* var. (or subsp.) **satan**, new.

Female and Worker.—Head, thorax and abdomen jet-black, scarcely with any ferruginous or yellowish markings; a very narrow inner border of the eyes, outer orbits, lower portion of clypeus, mandibles, hind margin of pronotum and a blotch on tegulae, very slightly suffused with reddish-brown. Antennae black, base and apex more or less tinged with chestnut-brown. Legs black; base of tibiae, outer side of fore tibiae, and fore tarsi more or less ferruginous; mid and hind tarsi dirty yellow to orange. Wings uniformly bluish-black, with black veins and costa; stigma dark brown.

Male.—Almost exactly like the female; very narrow inner orbits dirty yellow.

Holotype: Lassance, State of Minas Geraes, BRAZIL, female (Cornell Univ. Exped.).—*Allotype*: Bello Horizonte, State of Minas Geraes, BRAZIL, male (Cornell Univ. Exped.).—*Paratypes*: Lassance, one male and six females; Pirapora, State of Minas Geraes, three females (Cornell Univ. Exped.); Fazenda do Diamante, Corinto, State of Minas Geraes, one female (Ynes Mefia); La Esperanza, Dept. Cundinamarca, COLOMBIA, one female (E. Roba).—Holotype, allotype and six paratypes in the Department of Entomology, Cornell University; four paratypes at Museum

of Comparative Zoölogy, Cambridge, Mass., and one paratype at the Academy of Natural Sciences of Philadelphia.

The extreme melanistic form of the species, differing from the var. *erythrocephalus* in having the head also practically entirely jet-black.

16. *P. canadensis* var. (or subsp.) **weberi**, new.

Female and Worker.—Mostly black, with brownish tinges over some of the abdominal segments; most of head, most of pronotum, tegulae, a small spot in upper corner of mesopleura, and antennae (except for median black area of flagellum), mahogany-brown. Pale sulphur-yellow markings restricted to the large apical margin of first tergite (emarginate in the middle and separated from the black base by a reddish-brown area), the knees, the basal half or more of all tibiae, and all tarsi. Wings strongly infuscated, purplish-black in basal two-thirds, more russet in apical third.

Male unknown.

Holotype: Macuto near La Guaira, VENEZUELA, female (Neal A. Weber).—*Paratypes*: Macuto, three females (N. A. Weber); Caracas, Venezuela, three females.—*Holotype* and paratypes at the Museum of Comparative Zoölogy, Cambridge, Mass.; paratypes also at the American Museum of Natural History.

In general coloration of body and wings the var. *weberi* resembles the varieties *panamensis* and *amazonicus*, but it differs from these in the large yellow margin of the first tergite. This margin is much more extensive than in var. *annularis*, which, moreover, has uniformly purplish-black wings. It recalls var. *cinctus*, of the Lesser Antilles, but that form is fairly uniformly reddish-brown with entirely yellowish-russet wings. The var. *weberi* is also larger (fore wing 20 to 22 mm. long). It was obtained in the arid coastal area of Venezuela, covered with xerophytic scrub forest and characterized by the cactus, *Cereus griseus*.

17. *P. canadensis* var. (or subsp.) **wheeleri**, new.

Female.—Body and legs bright reddish-brown; only the ocellar area, sutures of the thorax, a median line over anterior half of mesonotum and a narrow stripe in concavity of propodeum (widened below), black; middle of flagellum infuscated. The following markings are yellow: clypeus, lower half of face, most of outer orbits and mandibles, under side of scape, apical fasciae on all tergites and on second to last sternites (reduced on first and second, very extensive on the others and more or less divided on each side by a wavy reddish line), the knees, the basal third of all tibiae, and most of

all tarsi. Wings moderately infuscated, somewhat purplish-black and tinged with russet basally and along anterior margin.

Male unknown.

Holotype: Bochibampo Bay, Guayamas, State of Sonora, MEXICO, female, March 3, 1937 (Wm. M. Wheeler).—*Paratypes*: Copete Mine, 30 Kilom. east of Carbo, State of Sonora, 4 females (F. C. Nicholas).—Holotype at Museum of Comparative Zoölogy, Cambridge, Mass.; paratypes also at the American Museum of Natural History.

Related to the var. *mexicanus*, from the Central Plateau of Mexico, but distinct by the extensively yellow head and legs and the partly russet wings. It is also near var. *comanchus* (which has the thorax almost wholly black) and var. *kaibabensis* (which has uniformly russet wings).

***Polistes exclamans* Viereck**

In 1931, G. Salt and I described a *Polistes bahamensis*, with two color forms, var. *bilineolatus* and var. *picturatus*, all from the Bahamas. I have since recognized that these Bahaman wasps are structurally not separable from the continental *P. exclamans*. Two forms of *exclamans* occur in the United States.

Polistes instabilis H. de Saussure (Syn.: *P. oculatus* F. Smith), from Mexico, the Republic of Honduras and Costa Rica, resembles typical *P. exclamans* in color. The males are readily distinguished by the very bulging eyes, the subquadrate clypeus and the slender antennæ (with all segments of flagellum at least twice as long as thick). I have not yet found reliable structural differences in the female and worker.

1. *P. exclamans*, typical.—This is a common wasp in the southeastern United States. I have seen it from North Carolina, South Carolina, Georgia, Florida, Texas, Louisiana (Baton Rouge; Olivier), Oklahoma, Arkansas, Kansas, Colorado and Arizona. Although somewhat variable in color, it is always well marked with yellow, often profusely so; the propodeum bears usually four yellow stripes; the wings lack the yellow-russet tinge of the Bahaman varieties and the mesonotum seldom bears yellow longitudinal lines. Some specimens from Metacumbe Key and elsewhere on the east coast of Florida, are somewhat transitional

between typical *exclamans* and the var. *bilineolatus*. Typical *exclamans* is readily confused with *P. fuscatus* var. *hunteri* or *P. fuscatus* var. *bellicosus*, and in collections it is often called also *P. crinitus* or *P. minor*.

2. *P. exclamans* var. (or subsp.) *louisianus*, new.

Female and Worker.—Reddish mahogany brown, with only the middle of the flagellum above, the extreme base of some of the abdominal segments and the outer side of the mid and hind tibiæ infuscate or blackish. Pale markings ivory-white and scanty: a narrow hind margin to the pronotum, most of tegulæ, anterior angles of scutellum, linear anterior margin of postscutellum, an elongate spot on mesopleura (beneath tegulæ), two narrow median stripes on propodeum (sometimes lacking), linear apical margins on first to third abdominal tergites (more extensive on the first; sometimes lacking on the third), knees, bases of tibiæ, and most of tarsi. Wings as in typical form, uniformly infuscate and purplish.

Holotype: New Orleans, LOUISIANA, female (Ed. Foster).—*Paratypes*: two females from the same locality.—Holotype and one paratype at U. S. National Museum; one paratype at Museum of Comparative Zoölogy, Cambridge, Mass.

In the absence of the male, the specific identity of this form is not quite certain. I suspected at first that these three wasps might be some form of either *P. crinitus* or *P. versicolor*, accidentally introduced by man. Structurally, however, the New Orleans wasps are indistinguishable from *P. exclamans*. On the other hand, I have never seen a specimen of either *P. crinitus* or *P. versicolor*, from Central and South America and the Antilles, colored like them. The reduction of yellow markings is quite unusual for *P. exclamans*.

3. *P. exclamans* var. *bahamensis* Bequaert and Salt (1931, Ann. Ent. Soc. America, XXIV, p. 793).—Known only from the Bahamas, where it occurs on Andros Island. This is the most distinct of the several color forms of the species.

4. *P. exclamans* var. *bilineolatus* Bequaert and Salt (1931, *op. cit.*, p. 796).—Known only from the Bahamas, where it is found on New Providence Island and Eleuthera.

5. *P. exclamans* var. *picturatus* Bequaert and Salt (1931, *op. cit.*, p. 797).—Known only from the Bahamas, where it is found on Acklin Island, Mariguana, Rum Cay, Crooked Island, Long Island, Watlings Island and Cat Island.

Polistes major Palisot de Beauvois

I have discussed this species on two previous occasions (1936, Ent. News, XLVII, pp. 7-13; 1937, Arch. Inst. Biol. Veget., Rio de Janeiro, III, pp. 173-174). It occurs from the southern United States to Brazil, as well as in the Bahamas, Cuba and Santo Domingo. It has recently been introduced into Puerto Rico.

KEY TO NEARCTIC COLOR FORMS OF *P. MAJOR*

1. Thorax more or less extensively marked with yellow. Abdomen with extensive yellow apical margins on all tergites, sometimes covering them almost entirely 2.
Body almost uniformly dark chestnut-brown; only the tarsi and blotches on the head yellowish. Wings uniformly brownish, costal area somewhat russet, veins and stigma chestnut-brown var. *castaneicolor*.
2. Ground color of body light ferruginous-brown. Wings uniformly russet-fuseous, slightly purplish var. *palmarum*.
Dark areas of body cinnamon-brown to blackish-brown. Wings dark cinnamon-brown, with a russet tinge and slightly purplish 3
3. Thorax very extensively marked with yellow, particularly on the propodeum typical *major*.
Thorax with reduced yellow markings, which are absent on the propodeum var. *bakeri*.

1. *P. major*, typical.—Known from Mexico, Guatemala, the Republic of Honduras, Nicaragua, Brazil, Cuba, Isle of Pines, Santo Domingo, Navassa Island and the Bahamas; recently introduced into Puerto Rico. In the United States it has only been taken in a few localities of southern Arizona; these specimens are colored exactly like those from farther south and from the West Indies.

2. *P. major* var. (or subsp.) *bakeri*, new.

Male.—Similar to typical *major*, but chrome-yellow markings much reduced on thorax, being restricted to collar of pronotum (narrowly above, very broadly on the sides) and part of scutellum and postscutellum (shading into cinnamon-brown); mesonotum, mesopleura, metapleura and propodeum black; major part of pronotum, four elongate spots on mesonotum and small spot on upper part of mesopleura, reddish-brown.

Female or Worker.—Agreeing with the male in the reduction of yellow on thorax, the propodeum being black, unstriped. The allotype is colored almost like the holotype. The female paratype has most of pronotum, scutellum and postscutellum, and a large spot in upper part of mesopleura chrome-yellow.

Holotype: San Antonio, Bexar Co., TEXAS, male (G. P. Engelhardt).—*Allotype*: Big Bend Park, Brewster Co., TEXAS, female or worker (Rollin H. Baker).—One female *paratype* with same data as allotype.—Types at Museum of Comparative Zoölogy, Cambridge, Mass. The male was selected as the holotype, being the only perfect specimen.

3. *P. major* var. *bonaccensis* J. Bequaert (1937, *op. cit.*, p. 174).—This form is known only from Bonacca Island, off the north coast of the Republic of Honduras. It is homeochromic with *P. carnifex* var. *ochreata* Spinola, which was also taken on Bonacca Island by Dr. M. Bates. On the neighboring island of Roatan he found only the typical form of *P. major*.

4. *P. major* var. *castaneicolor* J. Bequaert.—Known only from Mexico (State of Jalisco) and a few localities in southern New Mexico (Alamogordo) and in southern Arizona (Sabino Canyon, Sa. Cataline Mts.; etc.).

5. *P. major* var. *palmarum* J. Bequaert.—Known only from southeastern California and Lower California, Mexico (San José del Cabo).

Polistes fuscatus (Fabricius)

The most common North American species of the genus covers the entire United States and the southern areas of the Dominion of Canada, in southern Quebec, southern Ontario, southeastern Alberta and southern British Columbia (northernmost locality: Chilcotin, in about 52° N., farthest north for any American *Polistes*).³ It extends southward to Mexico, Guatemala and the Republic of Honduras; but its distribution is poorly known there. It has been introduced accidentally by man into the Bermudas, Jamaica, Barbadoes, the Society Islands and the Hawaiian Islands, where it is now more or less established. *Polistes fortunatus* Kirby, described from the Cape Verde Islands, appears to be one of the color forms of *P. fuscatus* (probably var. *nestor* Fabricius), imported by man from the New World. All published records of *P. fuscatus* from continental South America appear to be based upon a confusion with *P. pacificus* Fabricius, which is structurally very different.

³ There are as yet no records of *Polistes* from New Brunswick and Nova Scotia.

P. fuscatus is perhaps the most variable wasp in existence, with regard to color and also to certain structural characters (particularly the shape of the clypeus of the male). These matters will be discussed more fully later. In the present preliminary study, I have been as conservative as possible, retaining most of the forms named by my predecessors. I recognize eighteen varieties, sixteen of which occur in the United States; five are here described as new.

KEY TO COLOR FORMS OF *P. FUSCATUS*

The unusually wide range of variation of most color forms, or varieties, of *P. fuscatus*, makes it difficult to construct a workable key for their identification. Some of the varieties are placed twice in the key; but even this device will not take care of many transitional specimens, which must be named more or less arbitrarily. The key, moreover, is based on females (queens and workers) only. The males are always more extensively yellow than the corresponding females. They should either be bred or collected from nests or matched arbitrarily with the forms known to occur in the same geographical area.

1. Thorax (including mesonotum) predominantly bright yellow or orange-yellow, with narrow russet or blackish sutures; mesonotum sometimes with small ferruginous or blackish blotches. Abdomen and legs extensively or mostly yellow. Wings amber-yellow or infuscated and more or less purplish var. *flavus*.
 Thorax (at least mesonotum) predominantly black or light or dark ferruginous, often more or less marked with yellow 2.
2. Small forms of the Bahamas or of Central America. Very extensively yellow, particularly on the propodeum and first tergite. Fore wing 10 to 13 mm. long 3.
 Forms of the American continent, usually larger (except var. *hunteri*), much less extensively yellow; propodeum at most with narrow stripes 4.
3. Form of the Bahamas. Mesonotum with four yellow stripes. Most of second tergite yellow. Wings smoky and rather strongly purplish var. *maritimus*.
 Form of Central America. Mesonotum without yellow stripes. Second tergite mostly ferruginous. Wings yellowish-russet var. *neotropicus*.
4. Dark areas of thorax mainly black, without or with yellow or reddish markings 5.
 Thorax mainly light or dark ferruginous, with or without yellow or black markings 15.
5. Small form (fore wing 10 to 18 mm. long) of the southeastern United States. Thorax with at least pronotum and scutellum ferruginous;

- propodeum almost always with yellow stripes. Most tergites with yellow margins, the third and fourth usually extensively black. Wings slightly yellowish russet, more or less purplish in the radial cell var. *hunteri*.
Larger (fore wing 15 to 20 mm. long) and of a different color 6.
6. Yellow markings scanty, often reduced to narrow hind margins on pronotum and one or more tergites; disk of second tergite without yellow lateral spots, the sides not or only narrowly yellow 7.
- Yellow markings extensive, at least on abdomen; disk of second tergite either with at least traces of lateral spots or extensively yellow on the sides 10.
7. Mostly black; thorax and second tergite without or with mere traces of ferruginous blotches; propodeum rarely with yellow stripes; legs black or more or less ferruginous, with the tarsi conspicuously yellow var. *pallipes*.
Body and legs more or less ferruginous; either thorax or abdomen or both distinctly blotched with ferruginous (at least on second tergite) 8.
8. Abdomen mostly ferruginous; bases of tergites black, apices of one or more margined with yellow. Thorax more or less blotched with ferruginous; mesonotum as a rule uniformly black; propodeum often with yellow stripes var. *nestor*.
Abdomen mostly black 9.
9. Large (fore wing 15 to 19 mm. long). Thorax rather extensively blotched with ferruginous; mesonotum either mostly ferruginous or with two ferruginous stripes. Abdomen either entirely black or first and second tergites (or one of them) more or less blotched with ferruginous. Yellow markings often almost lacking; propodeum without yellow stripes, usually extensively ferruginous; sometimes first tergite with yellow margin var. *metricus*.
Medium-sized (fore wing 13 to 16 mm. long). Thorax not extensively ferruginous, often only with small blotches on pronotum; mesonotum as a rule uniformly black. Sides of second tergite and sometimes blotches on first, ferruginous. Yellow markings more or less developed; propodeum with or without yellow stripes; one or more tergites with yellow margins typical *P. fuscatus*.
10. Propodeum without yellow stripes; thorax mostly black. Second tergite black, with yellow margin and two large yellow lateral spots somewhat fringed with ferruginous; third to sixth tergites mostly yellow. Wings brownish-yellow; stigma and veins rufous var. *utahensis*.
Propodeum with at least traces of longitudinal yellow stripes 11.
11. Yellow color extending over most of the tergites; lateral spots (particularly of second tergite) large, either broadly connected with the yellow sides and hind margins or separated by a narrow and usually faint line 12.

Yellow color of abdomen restricted to sides and hind margins of tergites and two small, entirely free, lateral spots on some or all tergites (spots of first tergite sometimes lacking or connected with apical band) 14.

12. Head black and yellow only. Thorax not or scarcely marked with rufous. Black areas of second tergite as a rule not fringed with rufous. Wings amber-yellow; stigma and veins rufous

var. *aurifer*.

At least head and often also pronotum blotched with rufous. Black areas of second tergite often more or less fringed with rufous 13.

13. Rufous color of thorax and abdomen extensive. Wings slightly smoky and more or less purplish; stigma and veins russet var. *apachus*.

Rufous color either absent on thorax and abdomen or restricted to blotches on pronotum and fringes around the yellow areas. Wings yellowish-gray, very slightly or scarcely purplish; stigma and veins rufous var. *connectens*.

14. Black areas of second tergite either more or less replaced by rufous or broadly fringed with rufous. Pronotum and head usually much blotched with rufous. Wings smoky, markedly purplish; veins blackish, costa and stigma russet var. *variatus*.

Black areas of second tergite not or barely fringed with rufous. Pronotum and head scarcely rufous. Wings yellowish-gray, very slightly purplish; stigma and veins russet-brown var. *montanus*.

15. Large (fore wing 18 to 22 mm. long). Almost wholly and uniformly light ferruginous; only first tergite with narrow yellow margin (sometimes lacking); propodeum and postscutellum sometimes marked with yellow. Wings purplish-black; stigma and veins black

var. *rubiginosus*.

Not uniformly light ferruginous and often smaller, or else several tergites with yellow apical margins 16.

16. Thorax and head mainly light mahogany-brown, more or less blotched with black, practically without yellow markings. Abdomen mainly blackish, usually without yellow markings; first and second tergites often partly ferruginous; first tergite sometimes with narrow yellow margin. Large (fore wing 14 to 20 mm. long) var. *metricus*.

Blackish color of abdomen not contrasting with the light reddish-brown of head and thorax. Yellow markings usually more extensive, particularly on the abdomen 17.

17. Abdomen very extensively yellow, often almost entirely so; second tergite either mostly yellow, or extensively yellow on the sides, or with two yellow lateral spots 18.

Abdominal tergites only with apical yellow margins; second tergite without lateral yellow spots and not or only narrowly yellow on the sides. Wings slightly infuscated, somewhat purplish 20.

18. Yellow markings of thorax much reduced or almost lacking; mesonotum and propodeum without yellow stripes. Wings amber-yellow; stigma and veins russet. Large (fore wing 16 to 18 mm. long)

var. *centralis*.

- Yellow markings of thorax extensive; propodeum nearly always and mesonotum often with yellow stripes 19.
19. Small (fore wing 12 to 15 mm. long). Wings amber-yellow. (California) var. *anaheimensis*.
 Medium-sized or large (fore wing 15 to 18 mm. long). Wings slightly smoky and somewhat purplish. (Southern United States, from Arizona and Utah to Florida) var. *apachus*.
20. Yellow markings scanty and narrow, often reduced to hind margins of pronotum and of first tergite. Thorax mostly ferruginous, with blackish blotches on pleura and mesonotum; propodeum without or with narrow yellow stripes. Large or medium-sized (fore wing 15 to 20 mm. long) var. *nestor*.
 Yellow markings extensive on thorax and abdomen; as a rule most tergites broadly margined with yellow; propodeum almost always with broad yellow stripes 21.
21. Large (fore wing 15 to 20 mm. long). Black areas of abdomen absent or reduced to extreme bases of tergites var. *bellicosus*.
 Smaller (fore wing 10 to 18 mm. long). Third and fourth tergites usually extensively black var. *hunteri*.

1. *P. fuscatus*, typical.—Specimens agreeing in every detail with Fabricius' description and type, now at the University Museum in Kiel,⁴ are by no means common. They are occasionally found, together with various slight variants, in southern Massachusetts (for instance, on Cape Cod and Martha's Vineyard), Rhode Island, Connecticut, southern New York (particularly Long Island), New Jersey, Pennsylvania, Virginia, West Virginia, North Carolina (Southern Pines; Raleigh), Ohio (Columbus; Cleveland), Illinois (Havana), Michigan, Indiana (Bloomington), southern Iowa (Decatur Co.), and eastern Kansas (Blue Rapids). I have not seen typical *fuscatus* from Canada, and what has been recorded from there under that name was probably all somewhat aberrant var. *pallipes*. Moreover, it intergrades with var. *nestor* and var. *pallipes*, as it covers some of the territory of both. It is particularly hard to draw a line between typical *fuscatus* and var. *nestor*, and it might be more rational to unite these two, at any rate.

2. *P. fuscatus* var. *anaheimensis* Provancher.—This color form is peculiar to California, where it occurs as far north as 38° N. latitude.

⁴ Dr. Olav Schröder kindly compared a series of North American specimens with Fabricius' type.

3. *P. fuscatus* var. *apachus* de Saussure.—*P. texanus* Cresson I regard as a synonym. This form is common in Texas, western Oklahoma (Woodward Co.; Grand), New Mexico, Arizona, south-western Colorado and southern Utah; occasionally elsewhere (Henry Co., southeastern Iowa; Ft. Lauderdale, Florida). I have also seen it from the States of Sonora and Coahuilla, Mexico.

4. *P. fuscatus* var. *aurifer* de Saussure.—The common form of the species throughout California, Oregon and the State of Washington. It extends well into southern British Columbia (Vernon; Kaslo; Chilcotin), as well as into Idaho (Warren, Idaho Co.; Waha; Coeur d'Alène) and Nevada (Humboldt River). This wasp was introduced into the Hawaiian Islands many years ago (first published record in 1884, by W. F. Kirby) and in 1928 it was reported from the Society Islands.

5. *P. fuscatus* var. *bellicosus* Cresson.—A common form of the southeastern United States, which, however, does not extend as far north as *metricus*. I have seen it commonly from South Carolina (Dewees Id.), Florida, Alabama, Mississippi, Louisiana and Texas. It intergrades with var. *apachus*.

6. *P. fuscatus* var. *centralis* Hayward, 1933, Proc. Utah Ac. Sci., X, pp. 141 and 143, Pl. IX, fig. 13.—This form appears to be restricted to Utah and western Colorado. In southern Utah it intergrades with *apachus*.

7. *P. fuscatus* var. (or subsp.) **connectens**, new.

Female and Worker.—Head mostly yellow; vertex, occiput, a broad, hourglass-shaped spot about the antennae, and outer half of outer orbits, black; clypeus medially and outer orbits somewhat suffused with russet; antennae ferruginous, flagellum somewhat infusate above, scape with black spot near upper tip. Thorax mostly black, with a few rufous blotches on dorsal areas of pronotum and on scutellum and postscutellum, variable in extent; narrow fore and hind margins of pronotum, scutellum and postscutellum anteriorly, two broad median stripes and lateral spots on propodeum, and a spot on mesopleura beneath base of wing, yellow; sometimes two yellowish or russet longitudinal stripes or lines on mesonotum; tegulae russet, spotted with yellow. Legs mostly ferruginous; coxae black, streaked with yellow; femora, tibiae and tarsi more or less yellow on the outer side. Abdomen extensively yellow; a black spot, irregularly hourglass-shaped, in basal two-thirds of first tergite, more or less edged with ferruginous; a larger hourglass-shaped black spot over basal three-quarters of second tergite more or less edged with ferruginous which often forms spots at the extreme sides basad of the yellow; and median, irregularly quadrate black spots at base of succeeding tergites,

often partly ferruginous; the sternites are black with broad yellow apical margins and lateral spots. Wings subhyaline, suffused with amber-yellow; veins russet.

Male.—Sometimes similar to the female, though with the face more extensively yellow, without black about the antennæ; mesosternum and entire under side of coxæ yellow. Other males are more extensively ferruginous, being then hardly separable from those of var. *variatus*.

Holotype: Badlands west of Grassy Butte, McKenzie Co., western NORTH DAKOTA, female (N. A. Weber).—*Allotype*: same locality, male (N. A. Weber).—*Paratypes*: ALBERTA: Medicine Hat, several females and males (F. S. Carr; E. H. Strickland); Lethbridge (E. H. Strickland); Mayberries (E. H. Strickland).—NORTH DAKOTA: Badlands west of Grassy Butte; Junction of Cannonball and Missouri Rivers, Sioux Co. (N. A. Weber); Medora, one male (O. A. Stevens); Fargo (O. A. Stevens); Mandan (O. A. Stevens); Medora (C. H. Waldron); Sentinel Butte (O. A. Stevens); Mott (J. R. Campbell); Marmarth (O. A. Stevens); Beach (R. L. Webster); Hague (M. van Soest); Trottem (A. C. Fox).—MONTANA: Laurel, Yellowstone Co.—WYOMING: Torrington, Goshen Co. (G. B. Fairchild).—NEBRASKA: Squaw Canyon, Sioux Co. (H. G. Barber); Lodgepole, 4,050 ft., Cheyenne Co. (H. A. Scullen).—COLORADO: Texas Creek, (J. C. Bradley); Denver (J. Bequaert); Manitou (J. Bequaert); Clear Creek, 7,000 to 8,000 ft., Jefferson Co. (G. P. Engelhardt); vicinity of Fort Collins (23 mi. up Little Poudre Canyon and Spring Canyon) (A. B. Klots); Boulder (E. R. Becker); Boulder Co. (C. P. Custer); Berkeley.—*Holotype*, *allotype* and several *paratypes* at Museum of Comparative Zoölogy, Cambridge, Mass. *Paratypes* also in several other collections.

This color form seems to be characteristic of the northwestern portion of the Upper Sonoran life zone. It probably will be found also in parts of South Dakota and Kansas. Its occurrence in southeastern Alberta is of considerable interest.⁵ The region is apparently an Upper Sonoran island surrounded by Transition fauna. Professor Strickland informs me that several other southern insects have been taken there. The solitary wasps he sent me include *Odynerus annulatus* var. *geminus* Cresson, *O. anormis*

⁵ A female of the var. *connectens* was also taken on a window pane in a house at Edmonton, Alberta. This was certainly an accidental importation by man. No *Polistes* was ever found in the open in that vicinity.

Say, *O. aldrichi* Fox, *O. dorsalis* (Fabricius), *Pterochilus quinquefasciatus* Say, and *P. decorus* Cresson.

The var. *connectens* is clearly transitional between the var. *aurifer* and the var. *variatus*, and shows also some gradation to the varieties *apachus*, *montanus* and *utahensis*. It is most typical in North Dakota.

At Medicine Hat females were taken in flight during August and September and males early in September. On November 27 a female was found hibernating "under clod." On April 17 a female was caught at the flowers of Buffalo Berry, *Lepargyrea canadensis* (Linnæus).

8. *P. fuscatus* var. *flavus* Cresson.—This is the extreme xanthic variation of the species, common in Arizona, southern Nevada (Las Vegas, Clare Co.), southern Utah (St. George, Washington Co.; Hurricane, Washington Co.), parts of New Mexico (Rio Grande Canyon, south of Taos; Highrolls; Picacho), and western Texas (Devils River near Comstock, Valverde Co.; Big Bend Park, Brewster Co.). It should also occur in northern Mexico, but I have as yet seen no Mexican specimens. Evidently characteristic of the Lower Sonoran desert country, it intergrades to some extent with var. *apachus*.

9. *P. fuscatus* var. (or subsp.) *hunteri*, new.

Average size smaller than most other forms of *P. fuscatus*. Length (h.+th.+t.1+2), of female and worker, 10 to 12 mm.; of male, 10 to 12 mm. Length of fore wing, of female, 10 to 13 mm.; of male, 10 to 13 mm.

Female and Worker.—Variegated black and reddish-brown in fairly equal proportions and with many bright yellow markings. Head mostly reddish-brown, with the ocellar area of the vertex and hind face of occiput black, the upper side of scape and of most of flagellum fuscous, but the flagellum not ringed with black. Thorax black, with the pronotum mostly, four longitudinal stripes on mesonotum, and most of scutellum and postscutellum, reddish-brown; sometimes most of the mesonotum and blotches on mesopleura and sides of propodeum reddish; or the mesonotum entirely black. Abdomen: first and second segments mostly reddish-brown, usually with blackish base extending triangularly behind; third and fourth more brownish-black to black, turning reddish posteriorly near the yellow hind borders; fifth and sixth reddish-brown to black. Legs mostly reddish brown, with black coxæ and infusate bases of femora and apical half of hind tibiæ; tibial spurs ferruginous. Yellow markings as follows: broad apical margin of clypeus; lower inner orbits; entire outer orbits; narrow collar and hind margin of pronotum; broad anterior fasciæ on scutellum and postscutellum; a large spot on mesopleura

beneath base of fore wing; most of tegulæ; two broad longitudinal stripes and valvulæ of propodeum; broad apical margins of all tergites and most sternites (usually narrowed or interrupted medially on the sternites); lateral streaks or spots on first tergite, more or less connected with the apical band; apices of femora, outer side of tibiæ and most of tarsi. Wings moderately yellowish-russet, somewhat darker and slightly purplish over the radial cell; veins and stigma russet.

Male.—Similar to the female, but the yellow usually more extensive, covering most of the face, the entire clypeus, the oculo-malar spaces and most of outer orbits, the mandibles, the under side of the scape, most of the prosternum and under side of coxæ and femora.

Holotype: Paradise Key, Dade Co., FLORIDA, female (Richard Dow).—*Allotype*: Cape Sable Road, 5 mi. W. of Dade Co. Line, FLORIDA, male (Richard Dow).—*Paratypes*: VIRGINIA: Falls Church.—OHIO: Hocking Co.—NORTH CAROLINA: Southern Pines; Statesville; Raleigh; Wilmington; Morgantown; Kittrell; Kingsboro; Laurinbur; Havelock (Lake Ellis); Wadesboro; Conove; Aberdeen; Willard; Liberty; Ft. Bragg; Winston-Salem; Boardman; Fairmont.—SOUTH CAROLINA: Clemson College.—GEORGIA: Billy's Id., Okefeenoke Swamp; Roswell.—FLORIDA: Matecumbe Key; Monticello; Paradise Key; Ft. Lauderdale; Gulfport; Tampa; Tamiami Trail, Dade Co.; St. Petersburg; Jacksonville; Stuart; Miami; Kelsey City; West Lake, Dade Co.; Lutz; Clearwater; Titusville; Biscayne Bay; Charlotte Harbor; Gainesville; Key Largo; Lower Matecumbe Key; Orlando; Cape Sable; Coconut Grove; Crescent Grove.—ALABAMA: Thomasville, Clark Co.; Mobile; Leroy, Washington Co.; Biloxi; Auburn; Greenville.—MISSISSIPPI: Oxford; Winona.—LOUISIANA: Shriever, Terrebonne Co.; Darrow, Ascension Co.—TEXAS: Williamson Co.; New Braunfels; Dallas; Richmond, Fort Bend Co.; Carniso Springs; College Station (as prey of a robber fly).—OKLAHOMA: Quinton, Pittsburg Co.; Nowata Co.—MEXICO: Mexico, D. F.; Guadalajara, State of Jalisco; San Luis (de Potosi?); Cuernavaca, State of Morelos; Valle del Murz.—*Holotype*, *allotype* and many *paratypes* at Museum of Comparative Zoölogy, Cambridge, Mass.; *paratypes* also in several other collections.

This wasp is one of the most common insects of the southeastern United States. It looks like a diminutive var. *bellicosus*, with which it intergrades. In most cases it is readily distin-

guished from *bellicosus* by the small size and the predominance of black on the third and fourth tergites. Although the smallest *hunteri* are superficially very different from the other forms of *fuscatus*, they have all the structural characters of the species. In particular, the males always bear a minute tubercle on the middle of the seventh sternite. In addition it passes gradually into the var. *bellicosus*, so that some specimens must be placed arbitrarily. Some specimens of *hunteri* also resemble *P. exclamans* in color, but that species is structurally quite distinct (as shown in the key). In American collections and publications, this wasp is frequently called *Polistes minor*; but Palisot de Beauvois' wasp of that name came from Santo Domingo and it is structurally quite a distinct species from *P. fuscatus*.⁶

10. *P. fuscatus* var. (or subsp.) *maritimus*, new.

Female or Worker.—Head: most of face, vertex and occiput ferruginous, somewhat black around the ocelli and over a narrow streak on the vertex; clypeus, lower inner orbits into the ocular sinuses, oculo-malar space, cheeks (except in upper hind area) and mandibles, yellow; scape mostly and under side of flagellum ferruginous, upper side of flagellum black. Thorax: pronotum, scutellum, postscutellum and propodeum almost entirely yellow; pronotum and scutellum with small, dark ferruginous blotches; propodeum with a narrow, longitudinal black streak in the median groove; meso- and metapleura black with a series of yellow spots; sternum black; mesonotum black with four narrow, longitudinal yellow stripes, two median extending nearly the whole length, one short on each side above the tegula; tegula yellow with a ferruginous spot. Legs yellow, streaked with ferruginous along femora and tibiae, the hind tibiae more infuscated; tarsi ferruginous orange. Abdomen mostly yellow, with the following blackish or dark ferruginous markings: a small, basal, irregular spot on first tergite; narrow bases of most of the segments (more blackish on second and more ferruginous on remainder), that of second tergite expanding laterally and produced medially into an hourglass-shaped spot with three narrow apical projections; faint ferruginous lines set off yellow lateral spots from the apical margins on second to fifth tergites; sixth segment mostly ferruginous. Wings strongly infuscated, with pronounced purplish reflection, stigma and costa from base of wing to stigma, russet; remainder of veins black. Length (h. + th. + t. 1 + 2): 11 mm.; of fore wing, 12 mm.

Male unknown.

Holotype: Mangrove Cay, Andros Island, BAHAMAS, female,

⁶ The name *hunteri*, which I have adopted for this wasp, had been given to it in manuscript, at the U. S. National Museum, presumably by Ashmead.

May-June 1917 (Wm. M. Mann).—Type at Museum of Comparative Zoölogy, Cambridge, Mass.

Apparently a small insular form related to var. *hunteri*, of the southeastern United States, but much more extensively marked with yellow. It resembles superficially the West Indian *P. poeyi* Lepeletier and true *P. minor* Palisot de Beauvois. From the former it differs in the presence of the mesepisternal suture and the stronger striæ of the propodeum; from the latter in the shape of the clypeus and the striation of the propodeum. Since the male is as yet unknown, the var. *maritimus* is only tentatively placed under *P. fuscatus*.

11. *P. fuscatus* var. *metricus* Say.—There is a possibility that this wasp was described before Say as *Vespa geniculata* Gravenhorst (1807, Vergleichende Uebersicht Linn. u. einiger neuern Zool. Syst., p. 276; without locality). Until the type can be examined critically, I hesitate to adopt the name.—This form is common in the southeastern and central United States. I have seen it from New Jersey (Cape May), South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, eastern Texas (Williamson Co.; Brazos Co.; Dallas; Weslaco), Oklahoma, Arkansas, Tennessee, Missouri, Kentucky, southern Ohio (Pickaway Co.; Perry Co.; Hocking Co.; Buckeye Lake, Licking Co.), southern Indiana, Illinois (Chicago; New Columbia; Putnam; Urbana), Iowa (Mt. Pleasant), and Nebraska (Lincoln; Waverly). It should occur also in eastern Kansas. The distribution is much the same as that of *P. canadensis* var. *annularis*, which is more or less homeochromic and sometimes confused with it. The var. *metricus* extends much farther north in the valleys of the Mississippi, Missouri and Ohio than along the eastern seaboard. In certain areas it intergrades with other forms, particularly with var. *nestor*.

12. *P. fuscatus* var. (or subsp.) **montanus**, new.

Female and Worker.—Closely related to var. *utahensis* Hayward, from which it differs mainly in the presence of yellow stripes on the propodeum. Head: mostly black; lower third and broad sides of clypeus, lower inner orbits up to ocular sinuses, two streaks above bases of antennæ, a spot on upper outer corner of oculo-malar space, and much of mandibles, yellow; middle and upper part of clypeus (except the upper margin), blotches on oculo-malar space, a narrow streak on outer orbit, ocular sinuses, margins of

mandibles (except the black teeth), and antennæ (except a black streak on upper side of scape), ferruginous. Thorax: black; tegulæ ferruginous, spotted with yellow; narrow anterior and posterior margins of pronotum, two small spots near anterior margin of scutellum, narrow anterior margin of postscutellum, a short vertical streak in upper part of mesopleura (beneath base of wing), and two longitudinal stripes on propodeum (variable in extent, sometimes barely indicated), straw yellow; none of the specimens seen have any ferruginous on the thorax. Legs black; extreme apices of femora ferruginous on hind legs, ferruginous and yellow on fore and mid legs; fore and mid tibiæ ferruginous with yellow outer streak; hind tibiæ black, blotched with ferruginous and with yellow outer streak; tarsi mostly yellow, ferruginous toward apices; tibial spurs and claws ferruginous. Abdomen: mostly black; moderately large apical margins of tergites 1 to 5 and sternites 2 to 4 (somewhat wavy and more or less interrupted medially) and free spots of moderate size and irregular shape on the sides of tergites 1 to 5 (very small and sometimes absent on first tergite), placed rather close to hind margins, straw yellow; sixth segment ferruginous, the tergite with two small, basal yellow spots; the black of the fifth tergite is usually tinged with ferruginous and that color may in some specimens surround more or less the free yellow spots of the other tergites. Wings moderately infuscated, with a yellowish tinge and marked purplish reflection, especially in the apical third; veins dark brown; stigma and costa from base of wing to stigma, russet.

Male.—Differs only slightly from the other sex, with which it is readily associated. As usual, the yellow color covers the entire clypeus, face and oculo-malar spaces, and most of the under side of thorax, legs and abdomen; the upper side of thorax and abdomen are as in the female.

Holotype: Hamilton, Ravalli Co., MONTANA, female (W. J. Jellison).—*Allotype*: same locality, male (W. J. Jellison).—*Paratypes*: MONTANA: Hamilton, several females (W. J. Jellison); Ravalli Co., one female (W. J. Jellison); Willow Creek, Ravalli Co., four females (W. J. Jellison); Blodgett Canyon, Ravalli Co., one female (W. J. Jellison); Burch Creek, Ravalli Co., one female (W. J. Jellison); Lake Ronan, Lake Co., one female (R. D. Eichmann); Baird, Missoula Co., one female (A. L. Melander).—IDAHO: Wallace, Shoshone Co., one female; Pine Creek, Shoshone Co., 2,600 ft., one female.—OREGON: Corvallis (J. Schuh); 23 mi. W. of Halfway, 4,700 ft. (R. E. Rider); Pine Creek Canyon, 4,600 to 5,300 ft., Baker Co. (R. E. Rider); Umatilla, Umatilla Co., two females.—*Holotype*, *allotype*, and several *paratypes* at the Museum of Comparative Zoölogy, Cambridge, Mass.; *paratypes* also in several other collections.

Like the var. *utahensis*, this is an extreme variant of var. *aurifer*, seemingly connecting the two. In Oregon, where it occurs in certain localities together with *aurifer*, intergrades are also met with. As it appears to be the dominant color form of the species in Montana, it would seem to deserve a name.

13. *P. fuscatus* var. (or subsp.) **neotropicus**, new.

Closely related to var. *hunteri*, of which it has about the size, but more extensively marked with yellow, the propodeum being almost entirely of that color.

Female and Worker.—Head and antennæ ferruginous-red, the vertex more or less blackish about the ocelli; flagellum somewhat infusate above; clypeus as a rule entirely, broad lower inner orbits (as far as ocular sinuses), oculo-malar spaces, broad outer orbits and most of mandibles, pale yellow. Thorax ferruginous-red on pronotum and mesonotum, black on sternum and pleura (the mesonotum rarely more or less black); broad fore and hind margins of pronotum, tegulae, small spots on sides of mesonotum, most of scutellum and postscutellum, two spots on the mesopleura (one above the other), and most of propodeum (except a narrow median black line and broader black sides), yellow. Abdomen ferruginous-red dorsally, at most slightly infusate at the base of the third and fourth tergites, ventrally blackish-brown; apex and sides of first tergite very extensively (leaving only a ferruginous oval patch in the center), apical margins of succeeding tergites (narrow medially, much widened laterally and continued along the sides of the second tergite) and narrow spots in the hind corners of second and third sternites (sometimes continued as a complete apical margin on second sternite), yellow; sixth segment entirely ferruginous. Legs black, blotched with ferruginous; apical fourth to half of femora above, most of fore and mid-tibiae, basal two-thirds of hind tibiae, and most of tarsi, yellow; tibial spurs ferruginous. Wings moderately tinged with yellowish-russet, somewhat darker and slightly purplish over radial cell; veins and stigma russet.

Male.—Similar to the female, with which it is readily associated. Yellow more extensive on the legs, the under side of fore and mid coxae being mostly of that color. Two yellow spots on sternum.

Length (h. + th. + t. $1 + 2$), of female and worker, 10 to 12 mm.; of male, 11 to 12 mm. Length of fore wing, of female and worker, 10 to 13 mm.; of male, 11.5 to 13 mm.

Holotype: Puerto Castilla, REPUBLIC OF HONDURAS, female (J. Bequaert).—*Allotype*: Prieta, REPUBLIC OF HONDURAS, male (J. Bequaert).—*Paratypes*: Puerto Castilla, three females; Prieta, one female.—GUATEMALA, without more definite locality, five females and two males.—All types at Museum of Comparative Zoölogy, Cambridge, Mass.

14. *P. fuscatus* var. *nestor* (Fabricius).—This form is more extensively ferruginous over the abdomen than typical *fuscatus*, with which it intergrades. It is found occasionally on Long Island (New York) and in New Jersey, more commonly in southern Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida (Tangerine; Monticello), Alabama (Mobile), Kentucky, eastern Texas, southern Michigan (Midland Co.), southern Illinois (New Columbia; Herod), Indiana (Bloomington) and Ohio. There are many intergrades not only with typical *fuscatus*, but also with the var. *variatus*. All specimens I have seen from the Bermudas, Jamaica and Barbadoes were of the var. *nestor*, rather than typical *fuscatus*.

15. *P. fuscatus* var. *pallipes* Lepeletier.—*P. exilis* de Saussure appears to be a synonym. It is the extreme melanistic form of the species, characteristic of the northeastern part of the range, throughout the Transition life zone. I have seen it from southern Quebec (St. Jerome; Montebello; La Trappe; Montreal; Rigaud; Outremont; St. Remy; Queen's Park, Aylmer), southeastern Ontario (Frank' Bay, Lake Nipissing; Gull Lake; Pelee Id.), Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut (Colebrook), New York (including Staten Island and Long Island), New Jersey, Pennsylvania (Bartonsville; Pittsburgh; Braddock; Green Lane, Montgomery Co.; Mauch Chunk), West Virginia, Maryland (Plummers Id.), Ohio (Mahony Co.; Marietta), Indiana (Winona Lake), Illinois, Michigan (common), and northern North Dakota (Towner). It will probably also be found in Wisconsin and Minnesota. The northernmost locality is Towner, in about 48° 30' N. In the southern part of the range is intergrades with *nestor* and typical *fuscatus*. The extent of pale yellow markings varies greatly. Some specimens have only a narrow apical margin on the first tergite, narrow margins on the pronotum, the tegulae and two lines on the propodeum of that color. There are all passages to the other extreme, with broad apical margins on all tergites (often continued along the sides), yellow margins of pronotum, scutellum and post-scutellum, two broad stripes on propodeum (in one case even four stripes), a spot on mesopleura, and markings on the head. A few specimens may even show small, free, yellow lateral spots on the second tergite, thus simulating var. *variatus* and var.

montanus; they lack, however, the rufous blotches of the former and the yellowish-gray wings of the latter.

16. *P. fuscatus* var. *rubiginosus* Lepeletier.—*Vespa nigripennis* Degeer (1773) may have been this wasp, and if this is the case, Degeer's name will take precedence over Lepeletier's. This is a common wasp of the southeastern United States. I have seen it from southern Ohio (Blue Creek; Adams Co.; Lawrence Co.), Pennsylvania (Coraopolis), Virginia (Fredericksburg), North Carolina (Raleigh; Southern Pines), South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, eastern Texas (Comal Co.; Fort Bend Co.; Brazos Co.; Bastrop Co.; Kaufman Co.; College Station; Williamson Co.; San Antonio; New Braunfels; Austin), Arkansas, Oklahoma, Missouri, Kentucky, Tennessee, and southern Illinois (Olive Branch). It is better defined than other color forms of the species and shows little intergradation.

17. *P. fuscatus* var. *utahensis* Hayward, 1933, Proc. Utah Ac. Sci., X, pp. 141 and 142, Pl. IX, figs. 1 and 3-9.—This color form is known from Utah, Idaho, Nevada, Colorado, and Wyoming (Lava).

18. *P. fuscatus* var. *variatus* Cresson.—This is a fairly common form of the species in the Middle West: North Dakota (Fargo; Sheldon), Minnesota (Sleepy Eye), Nebraska (Lincoln; Cambridge), Iowa (common), Kansas (Manhattan; Wathena; Hays), Missouri, Illinois, Indiana, southern Michigan (common), Ohio, Kentucky (Buckeye; Mammoth Cave), Tennessee, Arkansas (Spring Dale), Oklahoma (Stillwater; Woodward Co.; Grand) and eastern Texas. I have also seen a few specimens from southern New Jersey (Lakehurst) and New Mexico (Carlsbad). In the northern parts of its range it intergrades with var. *nestor*, in Iowa with typical *fuscatus*, and in Texas and Oklahoma with var. *apachus*. Hayward's records of *variatus* from Canada (1933, Canad. Entom. LXV, p. 128) were, I believe, all due to a confusion with other forms of the species. Those from British Columbia referred to var. *aurifer*; the one male from Medicine Hat, Alberta, was my var. *connectens*; and the one male from Nelles Corner, Ontario, probably an aberrant var. *pallipes*. It is nevertheless, possible that the var. *variatus* may yet be found in southern Ontario.

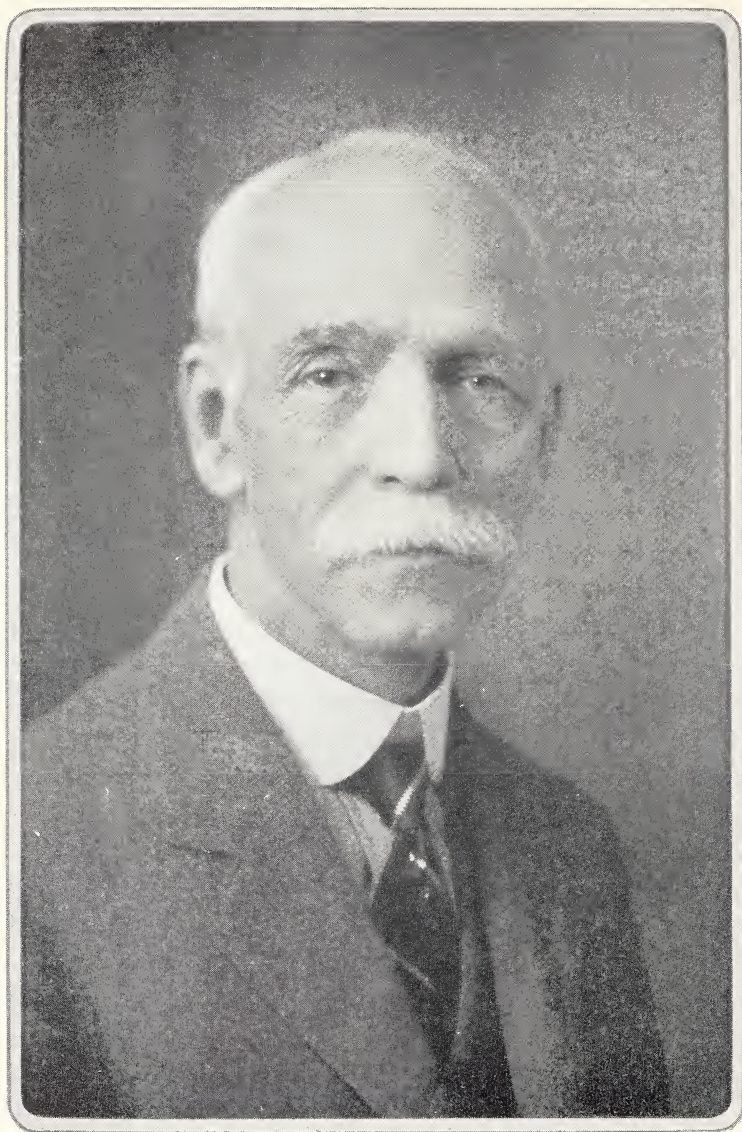
Postscript

The following remarks may prevent needless criticism. (1) For want of space it was not possible to enumerate the many museums and private collectors to whom I am deeply indebted for material or other assistance. (2) For the same reason the distribution of most forms is given by States only, except for the new and rare forms, or when more definite localities may help to define the geographical limits. (3) Structural characters could not now be illustrated nor their variation discussed. (4) More in particular, the male terminalia are not mentioned, because the specific differences they show are slight and could not be described adequately without figures.

BOOK NOTICE

Fleas of Eastern United States. By Irving Fox, Ames, Iowa.
The Iowa State College Press, February, 1940. 9 × 6 inches.
vii + 191 p., 31 pl. \$3.00.

This monograph on the fleas of eastern United States is a welcome addition to entomological literature. Many working entomologists have little exact knowledge of the various species of fleas and are apt to assume that a specimen is a certain species because it was found on a particular host. There is no longer any necessity for inconclusive identifications because Mr. Fox's work includes 55 species, in five families and 33 genera, found east of the one-hundredth meridian, exclusive of Texas. A brief introduction deals with the collection, preservation, morphology, terminology and life-histories of fleas in general while the balance of the book is devoted exclusively to keys to the suborders, families, genera, and species, together with descriptions of the males and females of each species, references to the literature of each species, detailed records of distribution, and eastern host records. There is also a synonymic index, a host index and a selected bibliography together with 31 plates embracing 166 figures, mostly of male genitalia and heads of males and females, which are of systematic importance. It may surprise many to find that various mammals are hosts to a half-dozen or more species of fleas. For example, the dog is host to six species, the cat to five, and *Homo sapiens*, that noble and self-important member of the order Primates, to nine. Fleas are important in view of their implication in the transmission of diseases and because they parasitize various mammalian and avian hosts. Entomologists and public health technicians in the east will find in Mr. Fox's book the facilities for identifying the various eastern species, without hunting through all the literature and in addition they will no longer have to be concerned with the inadequate and piece-meal bits of descriptive matter that occur in the general text-books on entomology.—H. B. W.



Sincerely yours.
H. C. Fall.

HENRY CLINTON FALL

Henry Clinton Fall was born on Christmas Day, 1862, at Farmington, New Hampshire, and spent his boyhood at this place. He graduated (B.S.) from Dartmouth in 1884, and received from the same institution in 1929 the honorary degree of Doctor of Sciences. He went to California in 1889, taught at Pomona High School 1892-1896, and was head of the Science Department (housed in its own separate building) of the Pasadena High School from 1896 through 1917. After his retirement he returned East and made his home with his dearly loved sister and her husband, Mr. and Mrs. Carl Adams Richmond, at Tyngsboro, Massachusetts, until his death, November 14, 1939. He never married.

He was a corresponding member of the American Entomological Society, and a Fellow of the American Academy of Arts and Sciences, of the American Association for the Advancement of Science, and of the Entomological Society of America.

He began to collect beetles at the age of fourteen and soon after his arrival in California, in 1889, was busily engaged in collecting and in exchanging specimens with other collectors. At the same time he was studying his beetles diligently and naming those sent to him for identification by many other collectors, the writer one of them. He continued this great service up to the very end. A few years ago there came to him, as a resulting gift of appreciation, the immense collection of one of our best known collectors (still living), Charles Liebeck, of Philadelphia.

Fall offered no papers for publication, however, until he was thoroughly qualified, and he was almost thirty-five years old when his first descriptions were published in the October, 1897, issue of the "Canadian Entomologist" in a paper entitled "A List of the Coleoptera of the Southern California Islands with notes and descriptions of new species." His final paper, "The North American Species of *Nemadus*," appeared in 1937 in the JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY. The Leng "Catalogue of the Coleoptera of America, North of Mexico," and its four Supplements, list the titles of one hundred and thirty papers

published by Fall during this period of forty years. Fifteen of these appeared in the pages of this JOURNAL. Altogether Fall described 1,453 new species of North American Coleoptera and 37 new genera. This total, though exceeded only by Leconte, Horn, and Casey, is far less important than the manner in which these descriptions were prepared and presented after the most painstaking study of the literature, of the Leconte and Horn types, and of all available material. As a result very few of his species have ever been challenged: what little synonymy is recorded, is of his own discovery.

He did not confine his studies to any particular family but demonstrated his wide knowledge of the entire order of Coleoptera in giving monographic treatment to a great number of difficult groups, such as *Acmæodera* (1899), *Agabus* (1922), *Agathidium* (1934), *Apion* (1898), *Bruchus* (1910), *Cœlambus* (1919), *Collops* (1912), *Diplotaxis* (1909), *Gyrinus* (1922), *Hydroporus* (1923), *Hymenorus* (1931), *Lathridiidae* (1899), *Malthodes* (1919), *Pachybrachys* (1915), *Podabrus* (1928), *Ptinidae* (1905), etc. Among his writings are three faunal lists of unusual value, "List of Coleoptera of Southern California" (1901), "Coleoptera of New Mexico" (with Cockerell, 1907), and a list of the species taken by him in Alaska in 1924, during his trip to that region with the Richmonds. All his papers relate exclusively to the fauna of North America; all are taxonomic.

Early in life he had the good fortune to make the acquaintance of Frederick Blanchard. Both of them were not only skillful and tireless collectors, but serious students as well, and they became the closest of friends. Soon after Blanchard's death (November 12, 1912) the Richmonds bought the Blanchard place at Tynngsboro, and Fall lived with them after he came back East in 1918. Their home continued to be, more and more, a shrine for students of Coleoptera to visit, as it had been during Blanchard's lifetime. It was indeed a delightful home to visit, hospitable, harmonious, inspiring. Seldom does one family, under one roof, have so much of interest to offer its guests. In this home there were three work rooms of varied sorts: one for Mr. Richmond, former patent attorney for the American Telephone and Telegraph Company; another for Mrs. Richmond, an accomplished genealogist; and the

third Dr. Fall's own "den" containing his library, his collection of both native and exotic beetles, and his other collections of butterflies, of postage stamps, and of post marks. The deepest attachment existed always between brother and sister, and he was blessed indeed to enjoy the loving devotion of this sister at all times and under all circumstances. The varied interests and hobbies of the three members of this household never precluded time and zest for other activities, and friendly discussions enjoyed by all in common. The Shermans were welcomed many times to this happy mecca on their way to and from Randolph, New Hampshire. Our last stop-over was in May, 1939, on our return from a week-end in the White Mountains. The hurricane of September, 1938, wrought great havoc at Tyngsboro, destroying nearly every tree on the Richmond acres, and the family were naturally still greatly depressed by this fact, but all were full of thankfulness that they themselves and their house had escaped injury. Fall was still as interested as ever in his beetles and much pleased to receive, while we were there, a letter from Dr. Reinhard announcing the sending of some of his newly described species of Texas *Phyllophaga*.

In 1916 or thereabouts, at my earnest request, Fall assumed the task of doing something about our much neglected *Dytiscidæ*. Chris. H. Roberts and I had been collecting them for a long time with great enthusiasm and success, but, at least in my own case, with very little actual study. Fall made various trips to Mount Vernon making extensive selections from my collection, and assembled countless other specimens from various sources. With all this material and his own collection before him, he studied at length our species of the family, in connection with the *Leconte* and other types, and many of Dr. Sharp's specimens loaned by the British Museum. Revisions of the genera *Cœlambus*, *Agabus* and *Hydroporus* and, later on, of *Ilybius*, resulted and about 100 new species of the family were thus made clearly known. At our various meetings during the course of these studies, besides the time spent by Fall in very deep application to his entomological problems, there were various pleasant relaxations and games, in which we could all participate, and in which Fall was always an enthusiastic and skillful contestant.

As was expected by his friends, and following Blanchard's example, Fall bequeathed his collection with all his types—the largest private collection of beetles in the United States—to the Harvard Museum of Comparative Zoology at Cambridge, where he had spent so much time studying the Leconte types.

A letter from Charles W. Leng pays this tribute of appreciation to Dr. Fall's life work:—

“Upon the foundation laid by Leconte and Horn, he continued for forty years with rare conservative judgment the work of making known our beetle fauna. In the uniform excellence of his descriptions and tables he was the greatest of recent authors.”

JOHN D. SHERMAN, JR.

THE DEATH-FEINTS OF *SITOPHILUS GRANARIUS* LINN., AND *SITOPHILUS ORYZÆ* LINN.

BY HARRY B. WEISS

The death-feigning instinct, which is well developed in many insects and which occurs frequently in many of the Coleoptera, is quite apparent in *Sitophilus granarius* Linn., and *Sitophilus oryzæ* Linn., in their reactions to outer stimuli. The following notes constitute a summary of observations made recently on the "reflex immobilization" of numerous specimens of these species, both of which were supplied to me by the kindness of Dr. William Moore.

Sitophilus granarius Linn.

The granary weevil, while crawling about over grains of corn, will not feign death if the grains are disturbed so as to touch the weevils only slightly. However, if the disturbance takes place persistently and with a little force, the death-feint occurs. And it takes place instantly when the weevils are touched with the tip of a pencil, or a pair of forceps. These weevils, which have only vestiges of wings, appear to be quite sensitive to mechanical stimuli.

The death-feint posture is unlike that of death. In general, the following attitude is assumed. The first pair of legs extends anteriorly close to the body and parallel to the head. The antennæ are also parallel with and close to the beak. The femora of the second pair of legs extend diagonally anteriorly, with the femora, tibiæ and tarsi folded upon each other. The femora of the third pair of legs extend posteriorly diagonally, with the femora, tibiæ and tarsi folded upon each other. The legs are all held close to the body. Sometimes the femora, tibiæ and tarsi of the first pair of legs are folded upon each other instead of being stretched out. Sometimes the antennæ stick out at various angles. And sometimes the legs do not all assume the rigid and fixed positions outlined above, but stick out grotesquely, or assume somewhat different positions. Apparently the intensity of the outside stimulus is important in determining the degree of rigidity.

The death-feint response in *S. granarius* may be brought about by various mechanical stimuli, such as turning the specimen over on its back, by picking it up with fingers or forceps, by dropping it from a height of two or three inches, by picking it up by one of its legs, by touching it almost anywhere on its body, although its dorsal surface is not so sensitive as its ventral one, by breathing upon it, by squeezing the antennæ and snout together, by pressing upon the ventral surface of the thorax, by pressing the sides of thorax and sometimes by vibrating the medium upon which it is resting. As a rule, death-feints, when the specimens were on their backs, lasted longer than when they were on their ventral surfaces, but there were many exceptions to this generalization.

The termination of the death-feint may be gradual or sudden. Usually the antennæ move first, then the first pair of legs and then the remaining pairs. In a gradual termination this sequence is easily observable. In a sudden termination, the recovery movements of these appendages appear to take place simultaneously.

During the course of the observations, the relative humidity varied from 36 to 40 per cent, the daylight or brightness from 4 to 150 candles per square foot, as measured by a Weston Photronic Exposure Meter, and the temperature from 68° F., to 94° F. As the relative humidity was almost constant, no further reference will be made to it. The brightness of the field in which the death-feint reactions were noted may also be neglected. Except for an instance of brightness approaching 150 candles per square foot, with a temperature of 73° F., the observations were made in fields where the brightness ranged from 4 to 65 candles per square foot, and this range will be immediately recognized as rather low. In all cases the degrees of brightness as noted appeared to have no effect upon the duration of the death-feint or upon the behavior of the insects. Temperatures, however, influenced the duration of the death-feint, as will be shown.

In the following Table I, there is shown the average duration in seconds of successive death-feints at various temperatures, of twenty-six weevils. The interval between the death-feints was approximately five seconds in duration. The longest number of successive death-feints was 104, after which the weevil refused

to react. There was considerable variation in the duration of individual death-feints but the general tendency was for the death-feints to become shorter as they successively increased in numbers. It may be noted in Table I that as the temperature became higher the average duration of the death-feints declined. At temperatures of 88° F., and above, many weevils refused to feign death at all. The death-feints that did occur were short and recovery was rapid. Many refused to perform after two or three successive death-feints lasting a second or two. When the

TABLE I

AVERAGE DURATION OF SUCCESSIVE DEATH-FEINTS OF SITOPHILUS GRANARIUS
AT VARIOUS TEMPERATURES

Temperature in degrees F.	Number of successive death feints	Average (arithmetic) duration in seconds
68	48*	15
68	72*	27
68	49*	58
70	21	38
70	16	34
70	14	29
70	18	36
70	11	40
72	104*	11
72	52*	23
73	11	35
73	4	37
74	48*	18
80	19	7
80	16	15
80	16	19
80	18	25
88	12*	6
88	29*	11
88	5*	3
88	2*	2
88	3*	1
94	2*	1
94	27*	4
94	6*	2
94	2*	2

* Indicates termination of death-feints.

death-feint was induced at a low temperature, it was ended immediately when the weevil was placed under the influence of the higher temperatures.

In view of the variation in the duration of successive death-feints the average time in seconds does not show how long or short some of the death-feints lasted. This omission is supplied in Table II. Depending upon the temperatures the death-feints lasted from one to as many as 207 seconds.

TABLE II

RANGE IN DURATION OF SUCCESSIVE DEATH-FEINTS OF *SITOPHILUS GRANARIUS*
AT VARIOUS TEMPERATURES

Temperatures in degrees F.	Range in seconds
68	1 to 60
68	2 " 80
68	2 " 207
70	3 to 118
70	4 " 140
70	5 " 65
70	5 " 122
70	4 " 95
72	1 to 71
72	2 " 79
73	11 " 100
73	25 " 59
74	1 " 56
80	1 to 14
80	4 " 29
80	4 " 45
80	7 " 89
88	1 to 10
88	2 " 27
88	1 " 7
94	1 to 2
94	1 " 6
94	1 " 4
94	1 " 2

The frequency distribution of the variations in the length of the death-feint at different temperatures is shown in Table III. At a temperature of 68° F., most of the recorded death-feints lasted from 1 to 30 seconds. Many longer death-feints occurred at this temperature but they were comparatively infrequent. At 72° F., most of the death-feints endured from 1 to 20 seconds, and at temperatures of 88° F., and above, the durations were from 1 to 10 seconds. Although the figures in Table III present some inconsistencies and do not indicate a fixed rate of progression from long to short death-feints as the temperatures increased, they do show that there is some correlation between the factors involved.

It is my belief that the variations in the durations of the death-feints, within certain temperature groups (except 88° and 94°) are due principally to variations in the intensities of the outside stimuli. It is impossible, without special apparatus, for an experimenter to apply mechanical stimuli, time after time, that do not vary in intensity. During the course of the work, it was

TABLE III

FREQUENCY DISTRIBUTION OF VARIATIONS IN THE DEATH-FEINT DURATIONS OF
SITOPHILUS GRANARIUS AT VARIOUS TEMPERATURES

Length of death-feint in seconds	Temperature in degrees F.							
	68	70	72	73	74	80	88	94
1-10	30	13	72	0	15	24	37	37
11-20	34	11	39	2	16	28	10	
21-30	38	18	23	8	7	9	4	
31-40	19	11	13	1	8	3		
41-50	17	5	3	1	1	4		
51-60	13	9	2	2	1	0		
61-70	4	4	2	0		0		
71-80	7	1	2	0		0		
81-90	1	1		0		1		
91-100	0	2		1				
101-110	1	1						
111-120	1	1						
121-130	2	2						
131-140	1	1						
141-150								
Over 150	1							

noted that long death-feints seldom resulted from slight stimulations. On the other hand, deliberate rough treatment such as pinching the front legs and beak together very firmly, frequently resulted in death-feints of comparatively long duration. In such cases the appearance of the weevil, with its legs drawn tightly to its body, indicated that the muscles controlling locomotion were in a tight state of contraction. As this state involved the antennæ also, the "hypnosis" probably extended throughout the nervous system. When the stimulus was slight, the muscular contraction was frequently not strong enough to draw the legs close to the body and they stuck out, sometimes at various angles. In most of these cases the death-feint was short and recovery was rapid, although in a few instances such "weak" death-feints lasted fairly long.

In order to determine how long a death-feint would last under prolonged stimulation, fifteen weevils were induced to feign death, and were then continually stimulated by being moved around and by pressure applied to the ventral surface of the thorax by the tip of a pencil or a pair of forceps. The durations of these death-feints in seconds at a temperature of 70° F., were 170, 300, 120, 28, 99, 434, 630, 635, 290, 1,290, 847, 2,160, 916, 434, 420, 384. The shortest was 28 seconds and the longest 2,160 seconds, or 36 minutes. The average length of the death-feint for the 15 individuals was 591 seconds, or almost 10 minutes.

Sitophilus oryzae

Rice weevils in infested grain crawl over each other and allow parasites to crawl over them, seemingly without any desire to feign death. However, if touched by something foreign, death-feints occur, but they are of short duration. On the whole this species does not seem as sensitive to outside stimuli as the granary weevil.

In the death-feigning attitude, the distal ends of the femora of the first pair of legs extend forward diagonally and are pressed against the base of the head. The femora of the second pair of legs extend forward diagonally and are held close to the body. The femora of the third pair of legs extend posteriorly diagonally, close to the body. In all cases the femora, tibiæ and tarsi are

folded upon each other, and held close to the body. The antennæ are parallel and close to the beak. In some cases the femora of the second pair of legs extend diagonally, posteriorly instead of anteriorly. Sometimes the antennæ participate only slightly in the muscular tension and do not assume a rigid attitude close to the beak. Frequently the tibiæ and tarsi are not folded close to each other but extend at wide angles from each other, although held close to the body. In other cases the legs stick out horizontally from the body. The death-feints of the rice weevil are comparatively brief. While assuming the death-feint readily if placed on their backs and with pressure applied to the thorax, they recover quickly. If handled and stimulated a few times they refuse to do anything except make efforts to escape. They are not very sensitive to outside stimuli. However, the death-feint may be brought about by squeezing the sides of the thorax, by pressing against the ventral surface of the thorax, by squeezing the antennæ and beak together or by dropping the weevil from a height of one or two inches. If one method fails, frequently another one will succeed. In some cases individuals are even susceptible to a slight touch against the edge of the body. All in all, it is a difficult insect to work with, especially if the temperature is 75° F., or above, and many individuals refuse to feign death at this and even lower temperatures, except when squeezed or pressed quite hard.

During the observations with the rice weevil, the same relative humidity, light and temperature conditions prevailed as were recorded for *S. granarius* and the same conclusions apply to both species.

Table IV shows the average duration in seconds, of successive death-feints at various temperatures of twenty-four rice weevils, the interval between death-feints having been approximately five seconds. The longest number of successive death-feints was 29, after which the stimulus no longer produced a reaction. Individual death-feints varied considerably but the tendency was for the duration to decline as the number of successive death-feints increased. This table also shows that as the temperature increased, the death-feints became shorter. At a temperature of 74° F., and above, many individuals refused to feign death at

all. When they did, the attitude of the legs was not tense; they were not held close to the body, and recovery was rapid.

TABLE IV
AVERAGE DURATION OF SUCCESSIVE DEATH-FEINTS OF *SITOPHILUS ORYZÆ* AT
VARIOUS TEMPERATURES

Temperature in degrees F.	Number of suc- cessive feints	Average (arithmetic) duration in seconds
68	16*	6
68	22*	12
68	8*	4
68	9	4
72	8*	4
73	8*	3
73	9*	12
73	3*	2
73	5*	4
74	12	7
74	17*	13
74	6*	6
80	3	1
80	5	2
80	29*	6
80	3	1
88	24*	4
88	2*	1
88	2*	1
88	4*	2
88	3*	1
94	10*	3
94	9*	2
94	2*	1

* Indicates termination of death-feints.

Tables V and VI deal with the range in duration of successive death-feints and with their frequency distribution with relation to various temperatures. Death-feints lasted from 1 to 40 seconds depending upon the temperature and the greatest number of them took place within the range of from 1 to 5 seconds. As with the granary weevil, it is believed that the variations in durations of the death-feints in *Sitophilus oryzae*, within certain temperature groups are due principally to variations in the intensities of outside stimuli.

TABLE V

RANGE IN DURATION OF SUCCESSIVE DEATH-FEINTS OF *SITOPHILUS ORYZÆ* AT
VARIOUS TEMPERATURES

Temperature in degrees F.	Range in seconds
68	1 to 12
68	2 " 7
68	1 " 10
68	1 " 10
72	1 " 10
73	1 " 13
73	2 " 2
73	5 " 40
73	1 " 6
74	1 " 36
74	1 " 11
74	2 " 19
80	1 " 2
80	1 " 4
80	1 " 20
88	1 " 9
88	1 " 3
88	1 " 2
94	1 " 5
94	1 " 3
94	1 " 1

TABLE VI

FREQUENCY DISTRIBUTION OF VARIATIONS IN THE DEATH-FEINT DURATIONS OF
SITOPHILUS ORYZÆ AT VARIOUS TEMPERATURES

Length of death-feint in seconds	Temperature in degrees F.						
	68	72	73	74	80	88	94
1-5.....	27	6	15	15	28	29	21
6-10.....	13	2	6	9	9	6	
11-15.....	4		2	3	1		
16-20.....	9		1	4	2		
21-25.....	1		0	1			
26-30.....	1		0	0			
31-35.....			0	2			
36-40.....			1	1			

Under continued stimulation at a temperature of 70° F., only a few could be induced to prolong their death-feints. Seven weevils, stimulated continuously, remained immobile for the following numbers of seconds before recovering: 33, 19, 40, 11, 26, 3 and 75. The average time was 34 seconds.

Although *Sitophilus granarius* and *Sitophilus oryzae* behave similarly in their reactions to contact stimuli under different temperatures, there is a great difference in the durations of their death-feints. In *granarius* it is brought about more readily and the locomotion reflexes are inhibited for a greater length of time. Both species exhibited the same nervous excitability after continued contact stimuli had brought about a condition in which the death-feint was no longer produced. And in high temperatures the reflex avoiding reaction took precedence over the "instinct" to feign death.

BUTTERFLIES OF NEW JERSEY

A LIST OF THE LEPIDOPTERA SUBORDER RHOPALOCERA OCCURRING IN
THE STATE OF NEW JERSEY; GIVING TIME OF FLIGHT, FOOD
PLANTS, RECORDS OF CAPTURE WITH LOCALITY AND DATE

BY WILLIAM PHILLIPS COMSTOCK

INTRODUCTION

The butterflies appeal to a great many collectors, though they probably represent only about one per cent of the listed insects of the state of New Jersey. Their numbers, as related to other insects occurring in the state, may be judged from the few pages devoted to them in the "Annual Report of the New Jersey State Museum for 1909" containing the Report of the Insects of New Jersey prepared by the late Professor John B. Smith. Here the butterflies were quite adequately covered but the list is out of print and at present copies are difficult to obtain.

The present list adds few to those known to occur thirty years ago as butterflies are mostly obvious creatures and future additions to the state list will probably occur more as strays than as permanent residents. The reason for this list is to record additional facts about some of the species, as to their way of life, and occurrence both for dates and new localities.

There are recorded in this New Jersey list 132 species and 39 sub-specifically named. In the list for New York State there are 130 species and 27 sub-specifically named. For Connecticut there are listed 87 species and 11 sub-specifically named. In a list of the butterflies of the District of Columbia there are 90 species and 13 sub-specifically named. A recent list for the state of Virginia gives 133 species and subspecies.¹

¹ "A List of the Insects of New York," Mortimer Demorest Leonard, editor-in-chief. Cornell University Agricultural Experiment Station, Memoir 101, 1926.

"Check List of the Insects of Connecticut," by W. E. Britton, Ph.D. State of Connecticut State Geological and Natural History Survey, Bulletin No. 31, 1920.

"The Butterflies of the District of Columbia and Vicinity," by Austin H.

In Smith's "List," as it is familiarly known, there are a number of localities mentioned which no longer exist as good collecting areas. Notable among these are localities in northern New Jersey, the Orange Mountain area, Paterson and Garrett Rock and Snake Hill. The old, easily accessible, collecting spots about the lower end of Greenwood Lake, Hewitt and Lake Hopatecong are much impaired. The Jamestown area of pine barren territory and marsh has also been injured. The same is true of the once wonderfully rich collecting area of Five-Mile Beach. These localities were formerly extensively collected in and many of the less common species recorded from them thirty or more years ago are now scarce or absent. Nevertheless in the absence of other records it has been necessary to make use of many records from these places in this list. The dates are reliable and useful as guides for search in other localities of similar nature, which have not suffered so much from despoilation.

The arrangement of the species occurring in New Jersey follows that of several much used text-books upon the butterflies and diverges but little from the arrangement used by Dr. Smith. The numbers given are those of McDunnough's list.² For the identification of species there are so many excellently illustrated books, notably "The Butterfly Book" by W. J. Holland, revised edition 1931, that keys or descriptions seem unnecessary.

For convenience and brevity a system of presentation is adopted in the statements concerning each species. The items to be covered after the family designation are ordered as follows: Genus—Species—Important synonym or marked change from Smith's "List"—American popular name—General locality—

Clark. Smithsonian Institution, United States National Museum, Bulletin No. 157.

"Preliminary List of the Butterflies of Virginia," by Austin H. Clark and Leila F. Clark. Proceedings of the Biological Society of Washington. Vol. 50, pp. 87-91, June 22, 1937.

² "Check List of the Lepidoptera of Canada and the United States of America," by J. McDunnough, Ph.D. 1938.

In the Hesperiidæ the arrangement is that of "The Hesperioidea of North America," by A. W. Lindsey, E. L. Bell and R. C. Williams, Jr. Denison University Bulletin, Journal of the Scientific Laboratories, Vol. XXVI, April 1931.

Specific synonymy is corrected where essential.

Characteristic environment—Usual time of year when adults are most numerous—Number of annual broods—Winters as; egg, larva, pupa, imago—Peculiarities of habit and remarks—Food plants—Recorded dates; earliest to latest—Selected records; locality, date, collector—Subspecifically named forms.

It is not always necessary or possible to give information on each item as outlined but each listing of a species follows this general form and if items are omitted the succession of items remains the same.

In many cases species are very local, confined to very small areas where their particular food plant grows. The larvae of some apparently feed upon only one kind of plant. Thus a species may be spread over a considerable region but will be found only in scattered small areas.

Eggs may be laid on the top of the leaf, underneath, singly and in groups and masses. Some *Lycaenidæ* lay eggs in flower-heads. The larvæ have varied feeding habits. Some are nocturnal feeders, some myrmecophilous, one carnivorous. Some larvæ feed openly; some hide by day in various ways, as in cover about base of the plant, in ants' nests about the lower stem, or in a protection of leaves spun together. Pupæ are generally concealed in various ways and are difficult to find. Mostly they are of a shape and color that makes them inconspicuous. Imagoes feeding generally on the nectar of flowers and other juices are mostly fond of the bright sun and go to cover quickly at the slightest clouding over.

The distribution of species in the state is often closely associated with physiography and vegetation. Dr. Smith accompanied his report with an excellent map and text defining the faunal regions. A later and more detailed discussion by Dr. Fox³ elaborates this.

The state is divided into two portions,—the Northern District and the Coastal Plain,—by the Fall Line which extends across

³ State of New Jersey Department of Agriculture, Bureau of Statistics and Inspection, Circular No. 138. "A Revised Annotated List of the Dermaptera and Orthoptera of New Jersey," by Henry Fox, 1928.

the state from Trenton to New Brunswick and thence to Jersey City. The term Fall Line refers to the line where the hard rocks of the northern part of the state meet and pass under the loose deposits of the southern half.

The Northern District has subdivisions of physiographic character which, extending north from the Fall Line, are the Piedmont Region, the Crystalline Highlands, the Appalachian Valley and the Kittatinny Range.

The Coastal Plain is subdivided, extending south from the Fall Line, into the Middle District (inclusive of the Delaware Valley), the Pine Barrens, the Coastal District (including the Coastal Strip, Salt Marshes and Barrier Beaches) and the Cape May Peninsula. These divisions of the Coastal Plain are based on the nature of the soils and are vegetational. These terms are used for defining the general distribution of species.

Information about the few butterflies which are of economic importance is given in the paragraphs on those species. A list of collectors' names is given with corresponding abbreviations which are used for reference in the text. In recording the plenitude of individuals of a species and date range the statements are for average conditions. There are years of scarcity and abundance; locally favorable conditions may at times produce large broods; again, normally common species may some years appear to be entirely absent. For the names of food plants Gray's "New Manual of Botany" (seventh edition) is followed.

I have searched thoroughly the pertinent entomological literature for records of New Jersey captures. I have also used the data given in Smith's "List" of 1909 as required. I am particularly indebted to Mr. Frank E. Watson for many records and facts and also criticism of the manuscript as a whole. Dr. William T. M. Forbes has given good advice and added information. Others who have aided by contributing records and suggestions are Mr. Ernest L. Bell, Mr. Otto Buchholz, Mr. Austin H. Clark, Mr. Cyril F. dos Passos, Dr. Willis J. Gertsch, Mr. Sidney A. Hessel, Mr. Charles Rummel and Mr. H. E. Wilford. Other collectors' records which are cited have been taken from published statements.

LIST OF COLLECTORS*

(Aa.) Eugene M. Aaron.	(Hy.) F. Hoyer.
(An.) Elmer Anthony.	(Jn.) Charles W. Johnson.
(Ang.) John B. Angleman.	(F.Jn.) Frank Johnson.
(Bar.) Roy Barnett.	(Kl.) Alexander B. Klots.
(Bl.) E. L. Bell.	(Kp.) Stanley T. Kemp.
(Br.) H. H. Brehme.	(Kr.) Wm. D. Kearfoot.
(Bt.) Wm. Beutenmuller.	(La.) Roy Latham.
(Bu.) Edward J. Burns.	(Lt.) Philip Laurent.
(By.) Ernest Baylis.	(Lz.) Frank E. Lutz.
(Bz.) Otto Buchholz.	(Mt.) Harvey Mitchell.
(C.) Wm. P. Comstock.	(N.) Alan S. Nicolay.
(Ca.) J. & J. Cahalan.	(New.) Lloyd Newsom.
(Cy.) John P. R. Carney.	(Pm.) Charles Palm.
(Dke.) V. A. E. Daeke.	(Pk.) A. S. Pinkus.
(Dn.) E. L. Dickerson.	(Ort.) A. E. Ortmann.
(Doll.) Jacob Doll.	(My.) Otto Mayer.
(Dow.) Robert P. Dow.	(Ru.) Charles Rummel.
(dP.) Cyril F. dos Passos.	(Sb.) Simon Seib.
(Ds.) Wm. T. Davis.	(Se.) Otto Seifert.
(Eng.) George P. Engelhardt.	(Sh.) Ernest Shoemaker.
(Fr.) George Franck.	(Sk.) Henry Skinner.
(Frd.) W. G. Freedley, Jr.	(Sm.) John B. Smith.
(Fox.) Wm. J. Fox.	(St.) Witmer Stone.
(Ge.) Willis J. Gertsch.	(Sto.) Robert W. Storer.
(Gr.) John A. Grossbeck.	(Su.) C. H. Sunderland.
(Hg.) Herman Hornig.	(W.) Henry W. Wenzel.
(Hl.) Gaylord C. Hall.	(Wat.) Frank E. Watson.
(Hm.) Frank Haimbach.	(Wt.) Wright.
(Ho.) W. J. Holland.	(Ws.) Henry Wormsbacher.
(Hs.) Sidney A. Hessel.	(Wi.) Harry B. Weiss.
	(Wf.) H. E. Wilford.

DANAIDÆ

Danaus Kluk

89. *plexippus* Linnaeus. Monarch, milkweed butterfly. Throughout state. Open country, meadows. April–November. Three broods (Wi–Dn). Migrant to south in late fall, does not overwinter in state, females return in spring to start first local brood. Records of males returning in spring also.

* Where (Sm) follows another reference it means that the reference occurs in Smith's "List." Occasionally these references are corrected to agree with the original references.

Eggs laid singly, usually on under surface of leaves. Reported as swarming in Florida Everglades in winter, both males and females. Larvæ, Tampa, Fla., March 1-21 (Bl). Milkweeds (*Asclepias*).

Lakehurst, April 25, (Ds)—Newark, Oct. 7, (C).

Recorded throughout state every month from spring to fall. Aberration *fumosus* Hulst, several captures.

NYMPHALIDÆ

Dione Hübner

158. *vanillae* Linnaeus. Gulf fritillary. Occasional visitor. Passion flower leaves (*Passiflora*).

Cape May; 7-Mile Beach; Camden Co. (Hm) (Sm).

Euptoieta Doubleday

159. *Claudia* Cramer. Variegated fritillary. Coastal Plain. Moist open fields. June-October. Three broods. Eggs laid singly. Occasionally locally common. Passion flower leaves, violets, pansy (Eng), orpine (*Sedum*) rarely (Wat).

Engelwood, July 6, (C)—South Amboy, Oct. 4, (C).

Cape May, June-Oct., (Hm); Barnegat Pier, Aug. 7-Sept. 30, (Br); Runyon, Sept. 5, (C); Lakehurst, July 14, (C); Arlington meadows, July 15, Aug. 20, (Ru); Woodridge, Sept. 10, (Mt); Hillside, Sept. 15, 20, (Ru).

Argynnis Fabricius

161. *idalia* Drury. Regal fritillary. Throughout state. Open country, moist meadows. Late June-September. One brood. Larva a night feeder, hiding by day. Winters as first stage larva. Eggs laid singly. The brood is long extended fresh examples appearing from late June to middle of August. Violets.

Mashipacong, June 29, (C)—Fairton, Sept. 16, (Br).

Jamesburg, June 30, July 1, Aug. 25, Sept. 3, (C, Wat); Newton, July 5, 23, (C, Wat); Englewood, July 13, (C); Ramsey, July 21, (Ge), 28, (C); Old Bridge, Aug. 4, (Wat); Waterloo, Aug. 16, (C).

Aberration *ashtaroth* Fisher. Schooley's Mountain (Ang) (Sm).

166. **cybele** Fabricius. Silver spot. Throughout state. Abundant in southern area. Low open country. June–September. One brood. Larva nocturnal feeder. Winters as first stage larva. Eggs laid singly. Violets.

Greenwood Lake Glens, June 22, (Wat)—Bowne, Sept. 16, (C).

Newton, July 5, 6, 10, 23, common (C, Wat); Jamesburg, July 1, 4, Sept. 3, (C, Wat); Ramsey, July 28, (C); Old Bridge, Aug. 4, (Wat); Atlantic Highlands, Aug. 8, (Wat); Waterloo, Aug. 5, 16, (C).

167. **aphrodite** Fabricius. Northern District. Open country and meadows. July–August. One brood. Larva nocturnal feeder. Winters as first stage larva. Eggs laid singly. Violets.

Greenwood Lake Glens, June 25, (Wat)—Bowne, Sept. 12, (C).

Mashipacong, June 28, (C); Jamesburg, July 4, (C); Newton, July 6, 23, (C, Wat); Englewood, July 13, (C); Waterloo, Aug. 5, (C); Fort Lee, Aug. 25, (C).

Brenthis Hübner

200. **myrina** Cramer. Little silver spot. Throughout state. Moist fields and meadows. May–September. Two broods. Winters as partly grown larva. Nocturnal feeder. Eggs laid singly on stem or leaf. Violets.

Jamesburg, May 24, (C)—Carlstadt, Sept. 23, (C).

Jamesburg, May 30, June 3, 15, 20, Aug. 25, Sept. 3, (C, Wat); Newton, July 23, (C, Wat); Ramsey, July 12, (Ge), July 28, (C); Old Bridge, Aug. 28, (Wat); Dennisville, Sept. 5, (C, Wat); Point Pleasant, Sept. 17, (C, Wat).

212. **bellona** Fabricius. Meadow fritillary. Throughout state. Moist fields and meadows. June–September. Two broods. The species is long lived and broods drawn out. Winters as larvae in various stages of growth. Nocturnal feeder. Violets.

Great Notch, May 2, 10, (Ru); Greenwood Lake Glens, May 30, (C); Cranford, July 10, (Ru); Ramsey, July 12, (Ge); Bowne, Sept. 12, (C); Andover, Sept. 16, (C).

Euphydryas Scudder

217. **phaëton** Drury. Baltimore. Throughout state. Swampy meadows. June–July. One brood. Sometimes locally numerous. Gregarious as small larvae, wintering in web, scattering in spring. Eggs laid in large clusters underneath leaf on turtlehead (*Chelone glabra*). In spring when larvæ scatter they feed more generally. On young ash shoots (Wat). Figworts (*Scrophulariaceæ*).

Greenwood Lake Glens, May 31, (C)—Ramsey, July 28, (C).

Greenwood Lake Glens, June 16, 22, 25, (C, Wat); Arlington, June 5, (Ru); Ramsey, June 9, (Ge); Hemlock Falls, June 28, July 2, (C); Cape May Court House, July 16, (Hl, Wat); Newton, July 23, larvæ, (C, Wat).

This species varies greatly from suffusion to absence of spots leading to a number of named aberrations: **superba** Strecker and **phaethusa** Hulst have been taken in the state.

Melitaea Fabricius

256. **harrisii** Scudder. Harris' checker spot. Locally, Northern District. Moist meadows. June. One brood. Winters as young larva. Eggs laid in patches underneath leaf. Larvæ gregarious. *Doellingeria umbellata*.

Ramsey, June 9, (Ge)—Stanhope, June 12, (Ru); Mashipacông, July 5, (Hl, Wat); Greenwood Lake Glens, June 22, 25, (C, Wat).

Phyciodes Hübner

263. **nycteis** Doubleday & Hewitson. Silver crescent. Locally, Northern District. Open grassy fields. June–July. One brood. Winters as partly grown larvæ. Eggs laid in clusters up to 100 underneath leaf. Sunflowers, especially *Helianthus divaricatus*, occasionally aster (Wat).

Millburn, June 15, (Ru)—Sloatsburg, N. Y., July 11, (C).

Greenwood Lake Glens, June 16, 22, 25, 27 (C, Wat); Lake Lackawanna, June 20, 30 (Ru).

Aberration **milburni** Rummel. Type locality Millburn, June 20, (Ru).

265. **tharos** Drury. Pearl crescent. Throughout state. May–October. Three broods. Winters as partly grown larvæ, gregarious, irregular development due to lethargy makes great variation in time of emergence of adult. Various asters.

Staten Island, N. Y., Mar. 29, (Ds)—Mountain View, Oct. 5, (C).

Regularly on the wing from early May to middle October and our most common butterfly. Form **marcia** Edwards is the spring brood. Aberration **packardii** Saunders. Several records.

Polygonia Hübner

285. **interrogationis** Fabricius. Semicolon. Throughout state. Borders of woodland and scrub. March–November. Two broods. Winters as imago, hibernating in hollow trees or other cover. Abundant, fond of feeding on fallen fruit in orchards. Eggs laid singly or in chains on under surface of leaves; larvæ partly gregarious. Elm, hop, hackberry.

Hemlock Falls, June 23, (C)—Newark, Sept. 22, (C).

Frequent from the middle of June through September. Form **umbrosa** Lintner is the summer brood.

286. **comma** Harris. Hop-merchant. Throughout state. Borders of woodland and open woods. March–November. Two broods. Winters as imago. Sometimes locally abundant. Eggs laid on under surface of leaf or stem. Larva forms a nest. Nettle, hop, elm.

Old Bridge, April 26, (C)—Fort Lee, Oct. 21, (C).

Greenwood Lake Glens, June 22, (Wat); Newton, July 23, (C, Wat); Caldwell, Aug. 20, (C). Form **dryas** Edwards is the summer brood.

288. **faunus** Edwards. Green comma. Kittatinny Range. Open woodland. March–November. One brood. Winters as imago. Very scarce in state, more common northward. Eggs laid singly on top of leaf. Birch, willow, currant, gooseberry.

Mashipacong Pond, July 6, (E. R. Watson in Coll. Wat);

Lake Lackawanna, Sept. 6, (Ru); Schooley Mountain (Aa) (Sm).

294. **progne** Cramer. Gray comma. Northern District. Open woodland. March–November. Two broods. Winters as imago. Not common. Eggs laid singly in notches at edge of leaf. Currant, gooseberry.

Hemlock Falls, April 20, (Wat)—Hamburg, Oct. 2, (C).

Camden, April 24, (Cy) (Sm); Irvington, June 11, 14, (Bz); Greenwood Lake Glens, July 18, (C); Stanhope, July 23, (Ru); Lake Lackawanna, July 12, Aug. 13, (Ru), Aug. 19, (Bz); Andover, Aug. 30, (C).

Form **1-argenteum** Scudder is the summer brood. Greenwood Lake Glens, July 1, 2, (Wat).

Nymphalis Kluk

295. **j-album** Boisduval & LeConte. Large tortoise-shell. Throughout state locally. Open woods and wood roads. March–November. One brood. Winters as imago. Occasionally locally common. Gregarious larvæ. Gray birch (*Betula populifolia*) (Wat).

Hemlock Falls, April 6, (C)—Barnegat Pier, Sept. 30, (Br).

Alpine, June 10, larvæ abundant, (Wat); Newton, July 6, 10, (C); Ramsey, July 7, (Ge); Green Village, July 7, (Ru); Barnegat City, Aug. 16, (Br) (Sm); Great Notch, Sept. 5, (Ru); Newark, Sept. 12, (C); Lakehurst, Sept. 17, (Ds) (Sm).

297. **milberti** Godart. Small tortoise-shell. Northern District. Open fields and meadows. June–October. Three broods. Winters as pupa and imago. Eggs in masses, sometimes laid beneath leaf, larvæ gregarious. Usually scarce but some seasons locally very numerous. Nettles (*Urtica gracillis* and *dioica*).

Hillside, July 10, (Ru)—Camden, Nov. 6, (Cy) (Sm). Paterson, July 20, Aug. 13, (Gr) (Sm); Swartswood Lake, July 25, (Ds) (Sm); Hemlock Falls, Aug. 17, (Wat); Hamburg, Oct. 2, (C); Harrison, Oct. 24, (C).

298. **antiopa** Linnaeus. Mourning cloak. Throughout state. Open woods, wood roads and edges of wet meadows. March–November. Two broods. Winters as imago. Eggs laid usually in a single layer encircling a twig; gregarious larvæ, often making a large colony, defoliate food plant. Control by arsenical sprays. Elm, willow, poplar, hackberry.

Hemlock Falls, Mar. 23, (C)—Newark, Oct. 23, (C). On wing almost everywhere throughout season.

Aberration **hygiaea** Heydenreich. Synonym *lintnerii* Fitch. Occurs in various gradations but is very scarce.

Vanessa Fabricius

299. **atalanta** Linnaeus. Red admiral. Throughout state. On flowers of field and roadside. April–November. Two broods. Winters as imago. Often abundant in fall. Somewhat migratory. Eggs laid singly on upper surface of leaf. Larva lives in a nest. Nettle, false nettle (*Boehmeria cylindrica*).

Old Bridge, April 26, (C)—Mountain View, Oct. 5, (C).

On the wing throughout season, but perhaps most common in September.

300. **virginiensis** Drury. Synonym *huntera* Fabricius. Painted beauty. Throughout state. On flowers of field and garden. April–November. Two broods. Winters as pupa and imago. Egg laid singly on top of leaf. Larva forms a nest. Everlastings (*Antennaria*).

Jamesburg, May 17–Oct. 10, (C).

Throughout season, but more common, July through September.

301. **cardui** Linnaeus. Painted lady. Throughout state. On flowers of field and roadside and in waste places. April–November. Two broods. Winters as imago. In some years it appears in considerable numbers and again seems entirely absent. A migratory species with a speed of flight 20 to 25 miles an hour. Egg laid singly on top of leaf. Larva makes a nest. Thistle, burdock, hollyhock.

Newton, July 23, (C, Wat)—New Brunswick, Sept. 23, (Wat). There are earlier and later records for New England states (Scudder).

Junonia Hübner

303. **cœnia** Hübner. Buck-eye. Abundant south of Fall Line, more sparingly in Northern District. On flowers of field and roadside. May–November. Two broods. Winters as imago probably as it does further south. Often common in Coastal District in late summer. Eggs laid singly on tips and underneath leaves. *Gerardia*, snapdragon.

Lakehurst, June 29, (C)—Hillside, Oct. 17, (Ru).

Arlington, Aug. 5, Sept. 5, (Ru); Milltown, Aug. 23, (C); Dennisville, Sept. 5, (C, Wat); Point Pleasant, Sept. 17, (C, Wat); South Amboy, Oct. 4, (C).

Basilarchia Scudder

322. **astyanax** Fabricius. Synonym *ursula* Godart. Blue viceroy. Throughout state. Borders of woodland and roadside. May–September. Two broods. Winters as small larva in hibernaculum formed from tip of leaf. Imagoes often numerous on fallen fruit in orchards. Wild cherry, apple, thorn, plum, poplar and willow.

Jamesburg, May 30, (C)—Carlstadt, Sept. 18, (C).

More numerous in July and August but on the wing through five months.

Form **albofasciata** Newcomb flies with *astyanax* but is scarce. Intergrades occur. Mr. Hall records 8 specimens from Highpoint, 4 in one day.

Mashipacong, June 28, (C); Ogdensburg, July 10, (Bl); Elizabeth, July 17, (Bz); East Brunswick, July 29, (Dow); Waterloo, Aug. 5, (C); Great Notch, Aug. 16, (Ru); Stillwater, Aug. 5, (F. Treuting); Stanhope, Aug. 15, (Mrs. F. G. Ruggles).

325. **archippus** Cramer. Viceroy. Throughout state. Borders of woods, roadsides and meadows. June–October. Two broods. Winters as small larva in hibernaculum. Eggs laid singly. Willow and poplar.

Jamesburg, June 15, (C)—Mountain View, Oct. 5, (C).

Jamesburg, June 20, July 4, Aug. 25, (C); Newton, July 6, 23, larvæ, (C, Wat); Ramsey, July 28, (C); Old Bridge, Aug. 4, (Wat); Dennisville, Sept. 6, (C, Wat); Carlstadt, Sept. 18, (C).

Aberration **lanthanis** Cook & Watson flies with *archippus*

but is scarce. Intergrades occur. *Athenia*, Aug. 13, (Wat); *Elizabeth*, Aug. 14, (Bz); *Arlington*, Aug. 20, (Ru).

Asterocampa Röber

327. *celtis* Boisduval & LeConte. Locally, Northern District. Open woods. June–September. Two broods. Winters as larva and perhaps imago (Edwards). Imago rests on leaves and tree-trunks in woods. Eggs laid singly or in small clusters on under side of leaf. Hackberry (*Celtis*).

Newton, July 10, '36, (C), larvæ, July, (dP, Wat); Lake Lackawanna, June 12, 28, July 5, (Ru); Great Notch, June 13, '37, (Bz); Burlington (By); New Brunswick (Bar); South Orange, July, larvæ (Pk); Swartswood Lake, Sept. 4, '37, (N); Lawrence Harbor, Aug. 20, fairly common (W. C. Frey).

329. *clyton* Boisduval & LeConte. Emperor. Locally, Northern District. Open woods. June–July. One brood. Winters as small larva. Eggs laid in masses, sometimes 500, on underside of leaf. Larvæ gregarious for three stages, then after hibernating, scattering. Imago with habits like preceding species but more frequently seen. Hackberry (*Celtis*).

Hemlock Falls, June 28–July 14, (C, Wat); *Arlington*, July 5, 15, 20, (Ru); *Newton*, July 6, 10, (C, Wat), larvæ, July, (dP, Wat).

Form *proserpina* Scudder flies with the typical form.

SATYRIDÆ

Enodia Hübner

96. *portlandia portlandia* Fabricius. Locally, throughout state. Wood paths and open spots in woods. July–August. One brood. Winters as larva. Grasses.

Newton, July 11, (C); *Palisades*, July 20, (Eng).

portlandia anthedon Clark. This seems to be the subspecies most frequently taken in the state.

Mountain Side, June 26, (Bz); *Hemlock Falls*, July 5, (Wat); *Lake Hopateong*, July 5, *Bear Swamp* near Ramsey, July 10, *Green Village*, July 8, (Bz); *Millburn*, July 8, 10, (Ru); *Ogdensburg*, Aug. 10, (Bl).

Note. The following records show distribution in the state without definite record of the form. Ramsey, July 23, (Ge); Livingston, July 26, 28, (Hs); Newfoundland, July 27, (Ds) (Sm); Paterson, July 16, Aug. 17, (Gr) (Sm); 5-Mile Beach, (Hm) (Sm).

Neonympha Hübner

100. *areolatus septentrionalis* Davis. As *phocion* Fabricius (Sm). Pine Barrens and Coastal District. Swamps with coarse grass. June–July. One brood. Winters as larva (Wat). Grasses.

Jones Mills, June 21, (St) (Sm); Lakehurst, June 28, (Wat), July 7, 11, 19, (Hs), type locality, July, (Ds); Richland, July 17, (Hl, Wat); Brown's Mills Jc., July 12, (Dke) (Sm); Da Costa, July 17, (Lt) (Sm); Toms River, July 27, (Dke) (Sm); Atlantic City, July, (Aa); Deal, July 9, (Ca).

Megisto Hübner

103. *eurytus* Fabricius. Throughout state. Open woodland. May–July. One brood. Winters as larva. Eggs laid singly. Grasses.

Bowne, May 28, (C)—Ramsey, July 28, (C).

Common generally through June and July.

Satyroides Scudder

106. *eurydice* Johann. Synonym *canthus* Linnaeus. Throughout state. Locally common in grassy bogs. June–August. One brood. Winters as nearly grown larva and possibly pupa. Eggs laid singly. Coarse swamp grasses and sedges (*Scirpus* and *Carex*).

Jamesburg, June 30, (C)—Runyon, Sept. 4, (C).

Newton, July 7, 11, (C); Ramsey, July 28, (C); Livingston, July 26, 28, (Hs); 5-Mile Beach, June (Hm).

Minois Hübner

117. *alope* Fabricius. Blue-eyed satyr. Throughout state. Open woods and brush. July–September. One brood.

Winters as larva on emerging from egg. Eggs laid singly. Grasses.

Newton, July 6, (C)—Carlstadt, Sept. 18, (C).

Green Village, July 15, (Ru); Waterloo, Aug. 16, (C); Woodridge, Sept. 10, (Mt).

Form *maritima* Edwards is more frequent below the Fall Line. Jamesburg, July 5, (C); South Lakewood, July 13, (Wat); 5-Mile Beach, July–Sept., common (Hm).

Form *nephele* Kirby occurs in the northwestern part of state. Newton, July 5, 7, (C); Mashipacong, July (Hl).

LIBYTHEIDÆ

Libythea Fabricius

336. *bachmannii* Kirtland. Snout butterfly. Locally, throughout state. June–September. Three broods. Winters as imago. Hackberry (*Celtis*).

Avalon, July 4, (Kp); Camden, July 9, (Cy); Fort Lee, July 11, (Ws); Greenwood Lake Glens, July 18, (C); Snake Hill, July 20, (Wat); Lakehurst, July 21, (Ds) (Sm); Atlantic Highlands, July 26, (C, Wat); Arlington, Aug. 13, (Ru); Morgan, larvæ (Wat).

RIODINIDÆ

Calephelis Grote & Robinson

346. *borealis* Grote & Robinson. Northern metal-mark. On limestone outcrops, Appalachian Valley and Kittatinny Range. Thickets and fairly thick woods. July. One brood. Winters as larva. The butterfly rests with wings open on a sun-lit leaf or a flower in small open spots in shady woods. Round leaf squaw weed (*Senecio obovatus*).

Newton, July 5–18, (Gr, Wt, dP, Wat, C); Delaware Water Gap, (Aa) (Sm).

LYCENIDÆ

Strymon Hübner

372. *m-album* Boisduval & LeConte. Occasional visitor, southern species. Oak.

Orange Mountains, April 28, (Br) (Sm); Atlantic City,

- June 11, (Aa) (Sm); Jamesburg, June 21, (Wat); Lake Hopateong, July 5, (Fr) (Sm).
373. **melinus** Hübner. Throughout state. Open woods and fields on flowers. May–October. Three broods. Winters as pupa. Eggs laid singly in flower heads. Flower and fruit feeder. Bush clover (*Lespedeza hirta*), other legumes. Pompton, April 24, (C, dP)—South Amboy, Oct. 4, (C). Jamesburg, May 8, (C); Camden, June 17, Sept. 17, (Cy) (Sm); Ramsey, July 16, (Ge); Manasquan, July 24, (C); Paterson, Aug. 3–17, (Gr) (Sm); Fort Lee, Aug. 23, (C); Dennisville, Sept. 7, (C, Wat).
380. **titus** Fabricius. Locally, throughout state. July–August. One brood. Winters as egg. Egg laid singly on twig (Seudder). Larva on wild cherry, by day about roots of small plants, myrmecophilous, night feeder (Wat). Pupae on wild cherry rootstalk below surface of ground, June 20, (C). Imago on flowers in bright sun. Sometimes common. Jamesburg, June 24, (C)—Old Bridge, Aug. 4, common (Wat). Ramsey, July 3, (Ge); Jamesburg, July 4, (Wat); Englewood, July 6, (C); Westwood, July 8–29, (Mt) (Sm); Dover, July 16, (Jn) (Sm); Paterson, July 17, (Gr) (Sm).
381. **acadica souhegan** Whitney. Crystalline Highlands, Appalachian Valley. June–July. One brood. Winters possibly as egg. Larva by day on leaves and stems of small plants of willow (*Salix discolor*), myrmecophilous (Wat). Imago on flowers, locally common some seasons. Ledgewood, June 29, (dP)—Ramsey, July 17, (Ge). Great Meadows, June 30, (dP); Hewitt, July 1, (C, Wat); Dover, July 5, (dP); Newton, July 6, (C); South Ogdensburg, July 7, (dP); Newfoundland May–June, larvæ (Wat).
385. **edwardsii** Grote & Robinson. Northern District. June–July. One brood. Winters as egg. Larvæ in ants' nests at roots of scrub, scarlet oak, late May (Wat). Imago on flowers. Greenwood Lake Glens, June 21, 28, (C); Newfoundland, July 3, (Ds) (Sm); Newark, July 4, (Br) (Sm); Newton, July 6, (C); Hewitt, May, larvæ (Wat).

387. **falacer** Godart. *calanus* Auct. Throughout state. June–August. One brood. Winters as egg. Larvæ feed on leaves of oak, hickory and butternut.

Paterson, June 24, (Gr) (Sm)—Camden, Aug. 1, (Cy) (Sm).

5-Mile Beach, July 3, (Hm) (Sm); Lakehurst, July 13, (Hs); Newton, July 23, (C, Wat); Ramsey, July 28, (C).

389. **liparops strigosa** Harris. Locally, throughout state. July. One brood. Winters as egg. Egg laid singly on terminal twig. Swamp blueberry (*Vaccinium corymbosum*) (Wat), shadbush.

Jamesburg, July 4, (Ds) (Sm)—Old Bridge, Aug. 4, (Wat).

Lakehurst, July 7, 13, (Hs); Ramsey, July 16, (Ge); Greenwood Lake Glens, July 18, (C); 5-Mile Beach, July 17–26, (Hm) (Sm); Hewitt, June, larvæ (Wat).

Mitoura Scudder

401. **damon** Cramer. Green hair-streak. Locally, throughout state. May and July. Two broods, second partial. Winters as pupa. Egg laid singly at tip of blossoming twig. Occasionally common. Red cedar (*Juniperus virginiana*).

Pompton, April 24, (C, dP)—Westwood, May 20, (Mt) (Sm).

Almonessen, April 29, (Hg); Lakehurst, May 10, (Hs).

Form *æstiva smilacis* Boisduval & LeConte. Synonym *patersonia* Brehme, Paterson, type locality, July 25, (Br). Greenwood Lake Glens, July 18, (C, Wat); Paterson, July 27, (Gr) (Sm).

Incisalia Scudder

403. **augustus** Kirby. Throughout state. Open scrubby places. April–May. One brood. Winters as pupa. Larva flower feeder. Frequently abundant, Pine Barrens. Sheep laurel (*Kalmia angustifolia*), blueberry (*Vaccinium*).

Paterson, April 8, (Gr) (Sm)—Hemlock Falls, May 30, (Bz) (Sm).

Jamesburg, April 18, 24, May 8, 17, (C); Lakehurst, April 29, abundant (Hs); Westville, April 25, (Sk) (Sm); Lake-

wood, April 21, May 25, (C); Greenwood Lake Glens, May 3, 10, (C, Wat).

405. *irus* Godart. Locally, throughout state. April–May. One brood. Winters as pupa. Egg laid singly at base of flower stem. Not uncommon, Pine Barrens. Wild indigo (*Baptisia tinctoria*) (Wat), lupine (*Lupinus perennis*).

Spotswood, April 26, (C)—Greenwood Lake Glens, May 30, (C).

Kanaus Mt., May 4, (dP); Jamesburg, May 8, 17, 30, (C); Lakehurst, April 29, (Hs, Wat); Anglesea, May 1, (Lt) (Sm); Clementon, May 16, (Jn) (Sm).

407. *henrici* Grote & Robinson. Locally, Northern District. Open places with low vegetation. May. One brood. Rare. Huckleberry (*Gaylussacia resinosa*).

Greenwood Lake, tops of ridges, April 25, May 10, (C, Wat).

Note. The several records given in Smith's "List" for this species are omitted as doubtful through misidentification.

409. *polios* Cook & Watson. Pine Barrens. April–May. One brood. Winters as pupa. Eggs laid among and about terminal flower buds. Occasionally numerous. Bearberry (*Arctostaphylos uva-ursi*).

Lucaston, April 10, (Dke) (Sm)—Lakewood, May 25, (C).

Type locality, Lakewood, April 21, 27, (Wat); Milltown, April 22, (Gr) (Sm); Jamesburg, April 18, 24, (C, Wat); Outcalt, April 21, (C); Lakehurst, April 29, abundant (Hs).

Aberration *davisi* Watson & Comstock. Type locality Lakehurst, April 29, (Wat).

413. *niphon* Hübner. Pine Barrens. Open woods. April–May. One brood. Winters as pupa. Eggs laid singly on pine sprouts. Not common. Pitch-pine.

Lakewood, April 21, (C)—Camden, June 18, (Sk) (Sm).

Lakehurst, April 29, May 10, (Hs, Wat), May 2 (Bz); Westville, April 29, (Sk) (Sm); 5-Mile Beach, May 7,

(Hm) (Sm); Clementon, May 9, (Lt) (Sm); Jamesburg, May 15, 17, 30, (C).

Feniseca Grote

419. **tarquinius** Fabricius. The wanderer. Locally, throughout state. May–October. Three broods. Winters as pupa. Found as occasional individuals resting on a sun-lit leaf in open woods. Eggs laid singly on alder twigs near lice. Larva carnivorous, feeding on woolly alder louse (*Prociphilus tessellata* Fitch), sometimes numerous.

Andover, May 14, bred (C); Caldwell, May 26, (C); Hillside, May 30, July 15, (Ru); Newton, July 18, (C); Hewitt, July 19, (Hs); Waterloo, Aug. 16, (C); Ramsey, Aug., (Ge).

Lycaena Fabricius

424. **thöe** Guérin. Large copper. Locally, Northern District. Damp meadows. June–July and August–September. Two broods. Winters as egg. Eggs laid singly on underside of leaves and petioles and among seeds. Local and not numerous. Yellow dock (*Rumex crispus*).

Arlington, June 6, (Ru)—Carlstadt, Sept. 23, (C).

Troy Meadows, June 7, (C); Paterson, June 12, Aug. 3, (Gr) (Sm); Snake Hill, July 23, (C, Wat); Rutherford, July 29, (Se); Woodridge, Sept. 10, (Mt); Waverly, Sept. 19, (Wat).

434. **epixanthe** Boisduval & LeConte. Small copper. Pine Barrens in cranberry bogs. June–July. One brood. Winters as egg. Eggs laid singly mostly underneath leaf. Frequently numerous in cranberry bogs. Cranberry.

Brown's Mills Je., June 17, (Dke) (Sm)—Toms River, July 15, (Hl, Wat).

Lakewood, June 25, (C); Jamesburg, June 21, July 5, (C); Lakehurst, July 2, 14, (C); Mashipacong, July, (Hl, Wat).

435. **phlaeas hypophlaeas** Boisduval. Common copper. Throughout state. May–October. Three broods. Winters as pupa. Egg laid singly on stem or leaf. Usually common. Sorrel

(*Rumex acetosa*).

Almonessen, April 29, (Hg)—South Amboy, Oct. 4, (C).

Jamesburg, May 8, 17, 24, 30, June 30, July 4, Sept. 3, (C, Wat); Newton, July 6, 10, (C); Atlantic Highlands, Aug. 8, (Wat); Bowne, Aug. 21, Sept. 12 (C); Carlstadt, Sept. 18, (C).

This species is subject to considerable variation. Seven named aberrations have been captured in the state:—*fasciata* Strecker, *obliterata* Scudder, *fulliolus* Hulst, *octomaculata* Dean, *banksi* Watson & Comstock, *fulvus* Rummel, *neui* Rummel. In some restricted areas the tendency to aberration seems considerable, frequent individuals showing divergence from normal maculation or color but in most localities the normal form is predominant and the aberrations are very scarce.

Everes Hübner

447. *comyntas* Godart. Tailed blue. Throughout state. Open country. May–September. Three broods. Winters as full grown larva. Eggs laid singly in flower heads. Usually common. Flowers of bush clover (*Lespedeza*), tick trefoil (*Desmodium*), other legumes.

Almonessen, April 29, (Hg)—South Amboy, Oct. 4, (C).

Continuously on the wing throughout season with overlapping of broods.

Lyceanopsis Felder & Felder

475. *argiolus pseudargiolus* Boisduval & LeConte. Common blue. Throughout state. Open moist woods. April–September. Three broods. Winters as larva and pupa. Spring brood often very common in open woods, summer broods more scattered and less frequent. Eggs laid singly in flower buds. Larva myrmecophilous (C, Wat). Flower heads of many plants:—*Cornus florida*, *Viburnum acerifolium*, *Cimicifuga racemosa* and *Prunus serotina*.

Form *vernalis lucia* Kirby. Form *vernalis marginata* Edwards. These two spring-forms occur with *pseudargiolus* (synonym *violacea* Edwards). There are intergrades of every degree. Sometimes the heavily marked forms predominate.

Hemlock Falls, March 29, April 20, May 4, (C, Wat); Greenwood Lake Glens, April 25, May 3, (C); Lakewood, April 21, May 18, (Wat); Hope, May 5, (C).

Form *vernalis neglecta-major* Tutt. This form follows the early spring forms and is intermediate in occurrence between them and the first summer brood.

Hemlock Falls, May 24, (Wat); Jamesburg, May 30, (C).

Form *æstiva neglecta* Edwards.

Jamesburg, June 15, 20, July 4, Sept. 3, (C, Wat); Newton, July 5, 10, 18, (C); Newark, Aug. 11, 17, (C); Point Pleasant, Sept. 13, (C, Wat).

PAPILIONIDÆ

The Papilionidæ in New Jersey are represented by several species of the genus *Papilio* which may be divided into three groups: *Aristolochia* swallowtails of which *P. philenor* is the representative; Fluted swallowtails including *P. ajax asterius*, *P. chresphontes*, *P. glaucus*, *P. troilus* and *P. palamedes*; Kite swallowtails represented by *P. marcellus*. Three genera may be used to classify the three groups, respectively: *Troides* Hübner, *Papilio* Linnaeus and *Iphiclides* Hübner. See "A Revision of the American Papilios" by Hon. Walter Rothschild, Ph.D. and Karl Jordan, Ph.D. (Novitates Zoologicae, Vol. 13, 1906).

Papilio Linnaeus.

1. *philenor* Linnaeus. Green swallowtail. Throughout state. Open fields on flowers, open woods. May–October. Three broods. Winters as pupa. Sometimes common locally. Eggs laid in bunches on upper side of leaf or stem. Larvæ gregarious. Dutchman's pipe (*Aristolochia*), wild ginger (*Asarum canadense*).

Greenwood Lake Glens, May 18, (Wat)—Andover, Sept. 16, (C).

Hewitt, May 30, (C); Hemlock Falls, June 10, (C); Newton, July 23, (C, Wat); Ramsey, July 28, (C); Fort Lee, Aug. 23, (C); 5-Mile Beach, July, (Hm); Saddle River, July, (Ge).

4. *ajax asterius* Cramer. *P. ajax polyxenes* Fabricius is the Cuban subspecies. Parsley swallowtail. Throughout

state. Open country. April–October. Two broods. Winters as pupa. Eggs laid singly. Sometimes so abundant as to be injurious on parsley, carrots and celery. Hand picking is the safest control. *Umbelliferae* generally.

Pompton, April 24, (C, dP)—South Amboy, Oct. 4, (C).
On wing throughout season.

Note. Rothschild & Jordan record a transitional specimen (female) to **calverleyi** Grote from Passaic, N. J. (Novitates Zoologicae, Vol. 13, p. 547, 1906).

12. **cresphontes** Cramer. As *thoas* Linnaeus (Smith's "List"). Orange-dog, Giant swallowtail. Throughout state. Open country. June–July and August–September. Two broods. Winters as pupa. Occasional occurrence, but where prickly ash is common several may be seen in a day. Eggs laid singly, usually on upper side of leaves. Prickly ash (*Zanthoxylum americanum*), hop-tree (*Ptelea trifoliata*).

Greenwood Lake Glens, May 18, 30, (Wat); Awosting, May 21, (Hs); Newton, July 23, seven specimens (C, Wat); Paterson, Aug. 12, (Gr)(Sm). Records of 1937—Green Village, Aug. 12, 16, (Ru); Lake Lackawanna, Aug. 10, (Ru); Newton, Aug. 10, Sept. 6, (Ru); Newark, Aug. 28, (C).

15. **glaucus** Linnaeus. Tiger swallowtail. Throughout state. Open country. May–September. Two broods. Winters as pupa. Eggs laid singly on upper surface of leaf. Larva spins a web on top of leaf where it rests while not feeding. Wild cherry, tulip-tree, apple, ash and poplar.

Jockey Hollow Park, April 20, (dP)—Bowne, Sept. 16, (C). On the wing for five months.

Form female **turnus** Linnaeus. This yellow female is more common than the black one in the state. Intergrades occur.

20. **troilus** Linnaeus. Sassafras swallowtail. Throughout state. Open country. May–September. Two broods. Winters as pupa. Eggs laid singly on under surface of leaves. Larva on upper side of leaf which it rolls together and fastens for concealment. Sassafras, spice bush.

Hemlock Falls, May 4, (Wat)—Carlstadt, Sept. 18, (C).
On the wing for five months.

22. **marcellus** Cramer. As *ajax* (Smith's "List"). Zebra swallowtail. Occasionally throughout state. May–August. Two broods. Winters as pupa. Eggs laid singly on upper side of leaf. Papaw (*Asimina triloba*).

Hemlock Falls, June 30, (Br) (Sm); Newfoundland, July, (Ds) (Sm); Jersey City, July 3, 4, five specimens (Ws); Lakehurst, July 7, (Hs); Woodridge, Sept. 10, (Mt); Anglesea (W).

PIERIDÆ

Pieris Schranck

82. **protodice** Boisduval & LeConte. Checkered white. Generally south of and sparingly north of the Fall Line. In waste places. May–September. Two broods. Winters as pupa. Large broods frequently occur followed by years of scarcity. Eggs laid singly. Cruciferæ, especially wild peppergrass (*Lepidium virginicum*) (Wat).

Riverton, April 16, (Jn) (Sm)—Hillside, Oct. 30, (Ru).

Lakewood, April 26, (Wat); 5-Mile Beach, May, (Hm) (Sm); Newark Meadows, June 1, Sept. 10, (Ru); Jamesburg, July 4, (C); Ramsey, July 20, (Ge); Paterson, July 30, (Gr) (Sm); West Orange, Aug. 25, (C); Harrison, Sept. 25, (An); Mountain View, Oct. 5, (C). Spring form **vernalis** Edwards is of sparse occurrence.

84. **virginiensis** Edwards. Records of *oleracea* (Smith's "List") probably refer to this species. Occasionally throughout state. May–June. One brood. Winters as pupa. Toothwort (*Dentaria diphylla*).

Garrett Rock, April 30, male (Wat); May 6, female (Kr); Paterson, May 6, female (Gr) (Sm); Blairstown, June 2, male (Kl); Camden, (Cy) (Sm).

86. **rapæ** Linnaeus. Cabbage butterfly. Throughout state. Open country. March–November. Three broods. Winters as pupa. Eggs laid singly. Introduced from Europe, this species is often injurious to cabbage, cauliflower, and kale and occurs on Cruciferæ generally.

Newark, April 5, (C)—Stockton, Nov. 19, (C).

On the wing commonly throughout the season. In the spring specimens without spots are occasionally taken and called **immaculata** by various authors.

Anthocharis Boisduval

30. **midea** Hübner (*genutia* Fabricius). Orange-tip. Locally, throughout state. Open woods. April–May. One brood. Winters as pupa. Sometimes very common in Northern District. Eggs laid singly anywhere on plant. Rock cress (*Arabis lyrata* and *perfoliata*) (Wat), *Sisymbrium thaliana*, Westville (Hg).

Manumuskín, April 24, (Dke)—Awosting, May 27, (Hs).

Greenwood Lake Glens and Awosting, April 25, May 10, (C, Wat), May 22, 27, (Hs); Almonessen, April 29, (Hg); Little Falls, May 14, (Ds) (Sm); Old Bridge, April 26, (C); Pompton, May 1, (C, dP, Ru); Oakland, May 2, (Ge); 7-Mile Beach, May, (Hm).

Phœbis Hübner

57. **sennæ eubule** Linnaeus. Cloudless sulphur. Coastal area and occasionally inland. Open country. August–October. Eggs laid singly on young leaves. A strong flier with migrant habits. Senna (*Cassia*). Princeton, Stony Brook Valley, larvæ on *Cassia marylandica* (Ort).

West Creek, Chatsworth, Hammonton, Pleasant Mills, Camden, Whitings, Aug.–Sept., (St); Barnegat Pier, Aug. 7–Sept. 30, common (Br); 5-Mile Beach Sept. “swarms” (Hm); Cape May, Sept. 18, ’32, migration observed, 50 counted in one hour (Pk); Beach Haven, Sept. 3, (Frd); Sept. 27 (Br); Cape May Co. and northward, Spring Lake, Aug., Sept., (Ho); Manasquan, Spring Lake, Sept. 2, Point Pleasant, Sept. 17, (Wat); Newark, Sept. 12, 13, (Ang); Franklin Park, Sept. 14, (Ru); Great Piece Meadows, Sept. 2, (C); La Vallette, late Aug., common (Joe Scheuerle).

Colias Fabricius

41. **eurytheme** Boisduval. Alfalfa butterfly. Throughout state. Open country. May–October. Two or three broods. Winters as larva. Eggs laid singly on top of leaf. Of this species, Dr. Smith remarked, thirty years ago:—“hardly a regular inhabitant of the state.” Since, in the last fifteen years, this species has become almost as numerous as *philodice*. Alfalfa, clovers.

Lakehurst, May 10, (Hs), July 3, (Ru); Green Village, June 24, Aug. 12, Oct. 30, (Ru); Bowne, Aug. 31, Sept. 3, 16, Oct. 13, (C); Harrison, Sept. 25, Oct. 3, 13, (An); Belleville, Oct. 10, (C); Hillsdale, Oct. 20, (C).

Form *æstiva* **amphidusa** Boisduval is the common form. The spring form *eurytheme* is rare. Form female **alba** Strecker occurs.

42. **philodice** Godart. Clouded sulphur. Throughout state. Open country. May–October. Three broods. Winters as larva. Egg laid singly on upper side of leaf. Clover and other legumes.

Lakehurst, April 29, (Hs)—Fort Lee, Oct. 21, (C).

On the wing throughout the season.

Form *vernalis* **anthyale** Hübner is of frequent occurrence in early spring. Form female **alba** Strecker occurs throughout the season.

Eurema Hübner

67. **nicippe** Cramer. Locally, Coastal Plain. September–October. Eggs laid singly, usually on underside of leaf. Senna (*Cassia*).

Barnegat Pier, Aug. 7–Sept. 30, not common (Br); 5-Mile Beach, Sept.–Nov., (Hm); New Brunswick, Aug. 23, Sept. 22, (C, Wat); Point Pleasant, Sept. 13, (Wat); Elizabeth, Sept. 14, (Gr) (Sm); Hillside, Sept. 5, 16, (Ru); Waverley, Sept. 25, (C).

72. **lisa** Boisduval & LeConte. Little sulphur. Throughout state. Common in Coastal District, less numerous above Fall Line. On flowers and moist earth. June and August–September. Two broods. Eggs laid singly on upper side of midrib of *Cassia marylandica* and *nictitens*.

Jamesburg, May 30, (C)—Oct. 12, (C).

Occurrence is sparse until August and September when it is often common.

HESPERIIDÆ

Epargyreus Hübner

484. **tityrus** Fabricius. Silver-spotted skipper. Throughout state. May–September. Two broods. Winters as pupa.

Eggs laid singly. Larva makes a nest by spinning leaves together and makes a slight cocoon to pupate. Locust and other legumes.

Jamesburg, May 17, (C)—Dennisville, Sept. 5, (C, Wat).

On wing throughout season.

Achalarus Scudder

496. **lyciades** Geyer. Throughout state. Fields, meadows and wood roads. May–July. One brood. Sometimes locally abundant. Rests with open wings while feeding on flowers. Tick trefoil (*Desmodium paniculatum*) preferred (Wat) and bush clover (*Lespedeza*).

Arlington, May 18, (Ru)—Greenwood Lake Glens, July 18, (Wat).

Green Village, June 6, (C); Lake Hopatcong, June 15, (Wat); Plainfield, June 21, (Ru); 5-Mile Beach, June, July, (Hm).

Thorybes Scudder

503. **bathyllus** Abbot & Smith. Throughout state. May–September. One brood. Winters as full grown larva. Bush clover (*Lespedeza capitata*) preferred (Wat); other legumes.

Jamesburg, May 24, (C)—Dennisville, Sept. 7, (C, Wat).

Cranford, June 10, (Ru); Newton July 6, (C); 5-Mile Beach, May–Aug., (Hm).

505. **pylades** Scudder. Throughout state. Fields and open woods. June–July. One brood. Winters as a full grown larva. Eggs laid singly on under side of leaves. Larva makes a nest by cutting and folding leaves. Clover and other legumes.

Hemlock Falls, May 25, (Wat)—Lake Hopatcong, Aug. 10, (C).

Great Notch, May 25, June 6, (Ru); Palisade Park, June 7, (Hs); Green Village, June 13, 16, (C); Greenwood Lake Glens, June 25, (Wat); 5-Mile Beach, May–Aug., (Hm).

Pyrgus Hübner

515. **centaureæ** Rambur. Crystalline Highlands. April–May.

One brood. Life history unknown. Formerly numerous at Paterson and Great Notch.

Normanock, April 25, (C, dP, Wat) ; Paterson, April 25, May 14, (Gr) (Sm), May 11, (Wat) ; Westwood, April 30, May 19, (Mt) (Sm) ; Great Notch, May 2, 6, (Ru) ; May 15, (C) ; Montclair, May 5, (Beut) ; Hewitt, May 18, (Wat) ; Awosting, May, (Hs) ; Iona, April 30, (Sk) (Sm) ; Pompton, May 1-6, (C, dP, Ru).

521. **communis** Grote. Synonym *tessellata* Scudder. Piedmont Region and southward. Dry fields and road sides. August-September. One brood. Winters as larva. Sometimes locally abundant. *Sida spinosa* (Wat), *Malva rotundifolia*, *Abutilon abutilon*, *Hibiscus trionum*. Bowne, Sept. 12, 21. Eggs and larvae (C).

Lakehurst, May 10, (Hs)—Bowne, Oct. 12, (C).

Stockton, Aug. 8, (C) ; Bowne, Aug. 21, 31, Sept. 12, 16, (C) ; Fort Lee, Aug. 2, (C) ; Nutley, Aug.-Sept., (New) ; Dennisville, Sept. 5, (C, Wat) ; Lakehurst, Sept. 10, 11, (Ru) ; 5-Mile Beach, Aug.-Oct., (Hm) ; Cape May, Aug. 27, (Pk).

Pholisora Scudder

531. **catullus** Fabricius. Throughout state. Roads and waste places. May-September. Two broods. Winters as full grown larva, pupating in spring. Eggs laid singly. Larva forms a nest of leaves. Pigweed (*Chenopodium album*), *Amaranthus* (Wat).

Jamesburg, May 24, (C)—Woodridge, Sept. 10, (Mt).

Throughout season, generally common.

Erynnis Schranck

541. **icelus** Scudder & Burgess. Northern District. Open woods. May-June. One brood. Winters as full grown larva, pupating in spring. Eggs laid singly on upper surface of leaves. Larva makes a nest of leaves and lives within for winter quarters. Willow, poplar (Wat).

Orange Mountains, May 1, (Bz) (Sm)—Greenwood Lake Glens, June 26, (C, Wat).

Jamesburg, May 8, 17, 24, 30, (C); Hillsdale, May 10, (C); Lake Hopatcong, June 15, (Wat); Newton, July 23, larva (C, Wat); Ogdensburg, May 30, (Bl).

542. **brizo** Boisduval & LeConte. Throughout state. Open woods. April–June. One brood. Winters as full grown larva pupating in spring. Oak.

Jamesburg, April 18, (C)—Lake Hopatcong, June 15, (Wat).

South Orange Mountain, April 19, (Wf); Jamesburg, April 18, 24, May 8, 17, 24, 30, (C); Hope, May 5, (C); Hillsdale, May 10, (C); Lakehurst, May 22, (Wat); Pompton, May 1, (C, dP, Ru).

547. **lucilius** Scudder & Burgess. Northern District. May–August. Two broods. Larva makes a nest of leaves and when full grown so winters, pupating in spring. Egg laid singly on under surface of leaf. Wild columbine (*Aquilegia canadensis*).

Paterson, April 19, (Gr) (Sm)—Andover, Sept. 16 (C).

Great Notch, May 3, (Bl); Greenwood Lake Glens, May 9, June 25, (Wat); Ogdensburg, May 22, June 3, July 11, Aug. 25, (Bl); Newton, July 5, 18, 23, larvæ (C, Wat).

546. **persius** Scudder. Possibly throughout state. Open fields and roads. April–May. Believed to be single brooded (Dr. Wm. T. M. Forbes). Winters as full grown larva. Willows and poplars (Scudder).

Old Bridge, April 26, Jamesburg, May 17, 24, Runyon, May 19, 26, Lakewood, May 22–24, (C); Greenwood Lake Glens, May 5, (Bl).

- **baptisiæ** Forbes. Possibly throughout state. May–August. Two broods. Winters as full grown larva. Wild indigo (*Baptisia tinctoria*) (Wat).

Greenwood Lake Glens, May 31, Fort Lee, Aug. 2, Waterloo, Aug. 5, Lake Hopatcong, Aug. 12, Hemlock Falls, Aug. 17, (C).

Note. For *E. lucilius*, *persius*, and *baptisiæ* see “The Persius Group of Thanaos” by William T. M. Forbes. Psyche, Vol. XLIII, No. 4, pp. 104–113 (1936). The

records given for the above three species were carefully verified.

550. **martialis** Scudder. Northern District. Fields and wood roads. May—June and July—August. Two broods. New Jersey tea (*Ceanothus americanus*).

Great Notch, April 27, (Bl)—Woodbury, Sept. 5, (Sk) (Sm).

Laurel Springs, April 29, (Hy) (Sm); Ogdensburg, May 22, 31, June 3, July 13, Aug. 11, 21, (Bl); Hemlock Falls, May 25, 31, June 8, (C, Wat); Greenwood Lake Glens, May 30, June 22, 25, (C, Wat); Jamesburg, June 15, (C); Newton, July 23, (C, Wat); Waterloo, Aug. 5, (C).

551. **juvenalis** Fabricius. Throughout state. Wood roads, oak scrub. May—July. Two broods. Winters as full grown larva. Eggs laid singly. Oaks, less commonly legumes (Wat).

Jamesburg, April 18, (C)—Newton, July 23, (C, Wat).

Jamesburg, April 24, May 8, 17, 24, 30, June 15, (C), July 17, (Pk); Lakewood, April 21, (C); Greenwood Lake Glens, May 3, 9, 30, (C); Bear Lake, Ramapo Mountains, May 3, (C).

554. **horatius** Scudder & Burgess. As *petronius* Lintner (Smith's "List"). Throughout state. Open fields. May—August. Two broods. Oaks, less commonly legumes.

Orange Mountains, April 25, (Ru)—Belleville, Aug. 18, (C).

Old Bridge, April 26, (C), Aug. 4, (Wat); Pompton, May 1, (C); South Lakewood, July 12, (Wat); Jamesburg, July 17, (Pk); Ramsey, July 28, (C); Waterloo, Aug. 5, (C).

Ancyloxypha Felder

567. **numitor** Fabricius. Throughout state. Rich grassy fields. May—September. Three broods. Winters as larva. Eggs laid singly. Larva forms nest of a grass blade. Grasses.

Jamesburg, May 30, (C)—Carlstadt, Sept. 18, (C).

Jamesburg, June 15, 20, 30, (C); Newton, July 6, 23, (C, Wat); Ramsey, July 28, (C); Old Bridge, Aug. 4, (Wat);

Bowne, Aug. 19, (C); Dennisville, Sept. 6, (C, Wat); 5-Mile Beach, May-Sept., (Hm).

Hesperia Fabricius

581. **metea** Scudder. Throughout state. May-June. One brood. Grasses.

Hemlock Falls, May 6, (C)—Lake Hopatcong, June 15, (Wat).

Jamesburg, May 8, 17, (C); Lakehurst, May 10, (Hs), May 20-27, (Ds) (Sm); Clementon, May 10, (Kp), May 15, (Lt); Millburn, May 4, 20, 28, (Ru).

591. **leonardus** Harris. Throughout state. Dry locations, on flowers. August-September. One brood. Winters as a small larva. Eggs laid singly. Grasses, *Agrostis*.

Fort Lee, Aug. 23, (C)—Point Pleasant, Sept. 17, (C, Wat).

Jamesburg, Aug. 25, (C, Wat); Lakehurst, Aug. 30, Sept. 2, (Ru); Atco, Sept. 5, (Lt); Dennisville, Sept. 5, (C, Wat); Hillsdale, Sept. 9, (C).

595. **attalus** Edwards. Pine Barrens. Swamps. July-August. One brood.

Lakehurst, June 24, 30, Aug. 14, 29, (Ru), July 22-Aug. 5, (Wf), July 10, 17, (Bz) (Sm); South Lakewood, July 12, (C, Wat); Da Costa, July 19, (W) (Sm); Clementon, Aug. 3, (Fox) (Sm).

598. **sassacus** Harris. Northern District. Meadows and fields. May-June. One brood. Winters probably as pupa (Scudder). Eggs laid singly on any low plant in grass. Grasses, *Panicum*.

Newfoundland, May 29, (Ds) (Sm); Greenwood Lake Glens, May 31, June 16, 22, 26, (C, Wat); Cranford, June 9, (Ru); Palisade Park, June 7, (Hs); Alpine, June 16, (C).

Hylephila Billberg

601. **phylæus** Drury. Throughout state. Meadows and grassy places. July-September. One brood.

Englewood, July 21, (Wat); Arlington, Aug. 18, (C); 5-Mile Beach, Aug. 20, (Hm) (Sm); Lakehurst, Aug. 26,

(Ru); Lake Hoptacong, Aug. 29, (Ds) (Sm); Dennisville, Sept. 7, (C, Wat); Bowne, Sept. 12, (C).

Atalopedes Scudder

602. **campestris** Boisduval. Probably from Fall Line southward. August–September. One brood. Bermuda grass (*Cynodon dactylon*).

5-Mile Beach, July 26, Sept. 20, (Hm) (Sm); Cranford, Aug. 1, (Bz); New Brunswick, Sept. 23, (Wat); Cape May, Sept. (Sk) (Sm); Camden, Aug., Sept., (Cy).

Polites Scudder

609. **verna** Edwards. Throughout state. Damp, open fields. June–August. One brood.

Elizabeth, June 20, (Bz) (Sm)—Jamesburg, Aug. 25, (C).

Runyon, July 2, Aug. 4, (C); Greenwood Lake Glens, June 22, 25, (Wat), July 18, (C); Lakehurst, July 11, (Hs); 5-Mile Beach, June 23, Aug. 12, (Hm) (Sm).

610. **manataaqua** Harris. Throughout state. Fields and moist meadows. June–July. One brood.

Elizabeth, June 20, (Bz) (Sm)—Cape May, Sept. 18, (Pk).

Greenwood Lake Glens, June 22, 25, (Wat), July 18, (C, Hs); Jamesburg, June 30, (C), July 2, (Pk), July 4, Aug. 25, (Wat); Lakehurst, July 7, (Hs); Ogdensburg, July 9, (Bl); Ramsey, July 10, (Wat); West Cape May, July 16, (Wat); Dennisville, Sept. 5, (C, Wat).

611. **themistocles** Latreille. Synonym *cernes* Boisduval & LeConte. Throughout state. Open country. June–September. Two broods. Winters as pupa. Eggs laid singly. Larva makes a nest and a slight cocoon for pupa. Grasses (*Panicum*).

Hemlock Falls, June 8, (C)—Bowne, Sept. 12, (C). On the wing in June and again in August and in September usually plentiful.

614. **peckius** Kirby. Throughout state. Open country. May–June and August–September. Two broods. Winters as full grown larva and pupa. Eggs laid singly. Grasses.

Jamesburg, May 30, (C)—Point Pleasant, Sept. 17, (C, Wat). On the wing in May and June and again through August and September, usually common. There are a few July records.

618. **mystic** Scudder. Northern District. In moist locations. June–July. One brood. Winters as larva. Eggs laid singly. Larva makes tubular nest of grass blades. Grasses.

Cranford, June 7, 9, 20, (Ru); Green Village, June 9, (Ru); Lake Hopatcong, June 15, (Wat); Greenwood Lake Glens, June 16, 22, 25, (C, Wat); Newton, July 5, (C); Ramsey, July 21, (Ge).

Catia Godman

621. **otho egeremet** Scudder. Throughout state. Open fields. June–August. One brood. Winters as larva. Grasses (*Panicum*).

5-Mile Beach, June 3, Aug. 27, (Hm) (Sm); Jamesburg, June 21, July 4, Aug. 25, 29, (C, Wat); Newton, July 6, 11, 23, (C, Wat); Greenwood Lake Glens, June 23, July 18, (C); Ramsey, July 28, (C).

Note. *otho otho* Abbot & Smith occurs in the south.

Poanes Scudder

622. **viator** Edwards. Locally, throughout state. Marshy land. July–August. One brood. Occasionally numerous in salt meadows. Grasses.

Arlington, July 19, Kearny, July 19, (Ru); Snake Hill, July 11, Aug. 2, (C, Wat); Anglesea, July 25, (Hm); Atlantic City (Aa).

623. **massasoit** Scudder. Locally, throughout state. Fresh water swamps. July–August. One brood. At times common. Grasses.

Westville, July 3–10, (Sk) (Lt) (Sm)—Westwood, Aug. 7, (Mt) (Sm).

Jamesburg, July 5, (C); Englewood, July 13, 21, (C); Helmetta, July 27, (Hs); Ramsey, July 28, (C); Green Village, July 2–22, (Ru).

Form **suffusa** Laurent. Type locality, Westville, July 4,

(Lt). Of fairly frequent occurrence there and at Malaga, July 17, (Hl, Wat).

624. **hobomok** Harris. Northern District. Edges of woods, fields and meadows. May–July. One brood. Winters as egg, larva and pupa (Lt). Grasses.

Paterson, May 11, (Gr) (Sm)—Westwood, July 5, (Mt) (Sm).

Hemlock Falls, May 24, (C); Greenwood Lake Glens, May 31, June 16, 22, 25, (C, Wat); Jamesburg, May 31, June 1, 20, (C); Palisade Park, June 7, (Hs).

Form female **pocahontas** Scudder flies with typical form.

625. **zabulon** Boisduval & LeConte. Locally, throughout state. Open woods and fields. May–September. Two broods. Grasses.

Belleville, May 23, (C)—Hillsdale, Sept. 9, (C).

Jamesburg, May 30, June 15, (C), Aug. 25, Sept. 3, (Wat); Cape May, May 30, (Sk) (Sm); Manasquan, July 24, (C); New Brunswick, Aug. 19, (Hs); 5-Mile Beach, June 19, Aug. 21, (Hm) (Sm); Newark, Aug. 28, (C); Hillside, Sept. 5, (Ru).

628. **aaroni** Skinner. Coastal District. Salt marshes. June–September. Two broods. Grasses.

Cape May, type locality (Sk), June 14, (Sk), Sept. (St, Pk); Anglesea, June 12, (Lt); 5-Mile Beach, June 15, Aug. 22–27, common in salt meadows (Hm); Dennisville, Sept. 7, (C, Wat); Tuckerton (Ds).

Atrytone Scudder.

634. **arogos** Boisduval & LeConte. Pine Barrens. Swamps. July–August. One brood.

Brown's Mills Jc., July 21, (Dke) (Sm); Brookville, July, (Ds) (Sm); Lakehurst, June 29, (Ru), Aug. 30, (Ds) (Sm).

635. **logan** Edwards. Dr. Smith lists *vitellius* Fabricius, a West Indian species. His records refer to this species. Throughout state. Damp fields. One brood. July. Grasses.

Lakehurst, June 29, (Ru), July 7, (Hs); Jamesburg, July 4, (C, Wat), July 30, (Ds) (Sm); Ramsey, July 10, (Ge); Westville, July 10, (Lt) (Sm); Lakewood, July 12,

(C); Stockholm, July 8, (Bl); Ogdensburg, July 11, 13, (Bl); Hewitt, July 19, (Hs).

638. **dion** Edwards. Pine Barrens, Appalachian Valley. July–September. Grasses.

Great Meadows, June 30, July 4, (dP); Anglesea, July 7, (Hm); Stockholm, July 8, (Bl); Lakehurst, July 22, Aug. 5, (Bz, Wf), July 19, (Hs), July 29, (Ds) (Sm); Jamesburg, Aug. 24, 31, Sept. 3, (Wat); Brown's Mills Jr., Sept. 15, (Dke) (Sm).

640. **conspicua** Edwards. Synonym *pontiac* Edwards. Throughout state. Damp meadows. June–August. One brood. Grasses.

Green Village, June 20, July 14, (Ru); Jamesburg, July 4, (Lt) (Sm); Westville, July 4, (Sk) (Sm); Westwood, July 4, 28, (Mt) (Sm); Newton, July 6, (C); Englewood, July 7, 13, (C); Lakewood, July 13, (C, Wat); Malaga, July 17, (Hl, Wat); Ramsey, July 24, (Ge); Old Bridge, Aug. 4, (Wat).

641. **bimacula** Grote & Robinson. Pine Barrens, Appalachian Valley. Swampy spots. June–July. One brood. Grasses.

Greenwood Lake Glens, June 16, 22, (C, Wat); Lakehurst, June 22, (Ru), June 24, (Wf), June 27, (Ds), July 7, 11, (Hs); Oak Ridge, June 26, July 3, (Sh) (Sm); Mashipacong, July 3–5, (Hl, Wat); Ogdensburg, July 7, (Bl); Stockholm, July 8, (Bl).

642. **vestris** Boisduval. Synonym *metacomet* Harris. Throughout state. July. One brood. Grasses.

Runyon, July 2, (C); Jamesburg, July 4, (C); Newton, July 10, 18, 23, (C, Wat); Green Village, July 15, (C); Newark, July 25, (C); Greenwood Lake Glens, July 18, (C); Ramsey, July 26, (Ge); 5-Mile Beach, July 27, (Hm).

Atrytonopsis Godman

644. **hianna** Scudder. Pine Barrens. May–June. One brood. Grasses.

South Lakewood, May 20, (Wat); Brown's Mills Jr., May 27, (Dke) (Sm); Iona (Dke) (Sm).

Amblyscirtes Scudder

660. **vialis** Edwards. Throughout state. Moist roadsides. May-June. One brood in New England but in south two broods (Scudder). A single brood probably in New Jersey. Grasses.

Clementon, May 15, (Hg); Lakehurst, May 20, June 4, (Ds) (Sm); Lakewood, May 22-25, (C, Wat); Jamesburg, May 24, (C); Newfoundland, May 29, (Ds) (Sm); Ogdensburg, May 30, (Bl).

661. **hegon** Scudder. Synonym *samoset* Scudder. May-June. Ogdensburg, May 31, (Bl); Green Village, June 8, (Ru).

Lerodea Scudder

671. **fusca** Grote & Robinson. Coastal Plain and a little above the Fall Line. Moist meadows. June-July and August-September. Two broods. Grasses.

5-Mile Beach, June 9, (Hm); Green Village, June 13, 16, (C), Aug. 19, (Ru); Jamesburg, June 15, 20, (C), June 22, (Ds) (Sm), July 4, (Sk) (Sm), Aug. 25, 29, Sept. 3, (Wat); Camden, June 18, (Sk) (Sm); Cape May Court House, July 17, (Hl, Wat); Ramsey, Aug., (Ge); Manasquan, Aug. 24, (C); Tuckerton, Sept. 2, (Ds) (Sm).

Prenes Scudder

680. **panoquin** Scudder. Coastal District. Salt marshes. June-September. Two broods.

Atlantic City, June 25-July 1, (Aa); 5-Mile Beach, June-Sept., common in salt meadows (Hm); Palermo, July 17, (Hl, Wat); Dennisville, Sept. 7, (C, Wat).

683. **ocola** Edwards

Bowne, Aug. 21, Sept. 12, '37, (C); Lakehurst, Aug. 24, '22, (Ru); Camden, Sept., common 1899 (Cy) (Sm); Salem (Aa) (Sm); Atlantic City (Aa).

Supplemental List

Included here are species of which sixteen have been captured in the state of New Jersey and three on Staten Island or Long Island. Of these fifteen species are of regular occurrence south of New Jersey. The records of these are given and under favor-

able circumstances more records of their occurrence may be expected but none of these species can now be regarded as a regular inhabitant of the state.

Phyciodes Hübner

266. **batesii** Reakirt. One brood. Wavy-leaf aster (*Aster undulatus*). The only record is from Gloucester in the original description in 1865. The species is of regular occurrence in western Pennsylvania and central New York State.

Basilarchia Scudder

321. **arthemis** Drury. White admiral. And form **proserpina** Edwards. In the last edition of Smith's "List" these were recorded. This is a northern species, frequent in the Catskill region of New York state and northward. It is believed to be out of range, even in the northwestern part of New Jersey. The reported captures are believed to be referable to *B. astyanax albofasciata* Newcomb. The recorded food plants of *arthemis* are black and yellow birch, basswood and willow. Two broods. Winters as larva.

Megisto Hübner

101. **mitchellii** French. Dover, Charles W. Johnson, July 10, 1890 (Sm). Identified by Dr. Henry Skinner. Woodport.
102. **sosybius** Fabricius. Southern New Jersey. Grasses. Mount Holly (Aa) (Sm). The species is abundant in the southern states.

Atlides Hübner

356. **halesus** Cramer. Occasional visitor, southern species. Mistletoe. Cape May, Gloucester, Westville (Aa) (Sm).

Strymon Hübner

365. **cecrops** Fabricius. Occasional visitor, southern species. Manasquan, June 29, one male (Br) (Sm); East Marion L. I., N. Y., Aug. 14, two specimens (La).
374. **favonius** Abbot & Smith. Occasional visitor, southern species. Anglesea, Sept. 1, two specimens (Hm) (Sm).

376. *autolycus ontario* Edwards. Newark, bred from larva found on oak, May 29, emerged June 13, 1892 (Doll collection). This is a very scarce form of which there are about a score of records during a half century. These records extend from Missouri to Massachusetts and Canada.

Erora Scudder

418. *laeta* Edwards. Atlantic City, July 1, (Aa). Two broods. This species is apparently rare but extends over a very wide range occurring abundantly in Arizona, and recorded scatteringly in Pennsylvania, New York, New England states and eastern Canada.

Papilio Linnaeus

21. *palamedes* Drury. Rare visitor from south. Red bay (*Persea borbonia*). West Hoboken, July 8, 1908 (Ws?); Delaware, Aug. 20, 1934, (Sto); Fort Wadsworth, S. I., N. Y., June 18, (Bu).

Appias Hübner

78. *ilaire* Godart. Southern species. Canarsie, L. I., N. Y., June 10, 1906, two specimens (My) (det. Wat).

Phœbis Hübner

58. *philea* Linnaeus. Southern species. Asbury Park, Sept. 9, (Eng); Riverside Park, New York City, Oct. 13, (Eng).
60. *agarithe* Boisduval. Southern species. Beach Haven, Sept. 3, male (Frd).

Zerene Hübner

55. *caesonia* Stoll. Dog-faced butterfly. Southern species. Eggs laid on under side of end leaves. False indigo (*Amorpha fruticosa*), also reported on clover. Flushing, L. I., N. Y., July 12, (Bl); Staten Island, N. Y., June, July, 1896 (Ds) (Sm).

Goniurus Hübner

486. *proteus* Linnaeus. Coastal District. August–September. Very rare as far north as New Jersey. Injurious to beans

in the southern states. Legumes. 5-Mile Beach, (Hg) (Sm); Cape May (Aa) (Sm).

Cecropterus Herrick-Schaeffer

500. **cellus** Boisduval & LeConte. Southern species. Hog peanut (*Amphicarpa pitcheri*), *Breweria aquatica*. Newark (Sm).

Polites Scudder

619. **brettus** Boisduval & LeConte. Southern species. August-September. Camden, 1 female, Aug. 10, 2 males, Sept. 7, (Cy) (Sm).

Oligoria Scudder

652. **maculata** Edwards. Southern species. Camden, 1 male, 1 female, July 15, (Cy) (Sm).

Lerema Scudder

653. **accius** Abbot & Smith. Southern species. Grasses. Salem (Aa) (Sm); Atlantic City, July, (Aa).

Calpodes Hübner

677. **ethlius** Cramer. Canna skipper. Southern species. No record in state but taken at several places on Long Island in 1911. Occasionally destructive to canna. Yaphank, L. I., May 27, (Fr); Floral Park, L. I., larva, Sept., Oct., (Eng).

THE RELATION OF ANTS TO THE JAPANESE BEETLE AND ITS ESTABLISHED PARASITES¹

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INTRODUCTION

It has long been known that many ants derive most of their food from dead and dying insects, and ants have been observed molesting both adult and larval stages of the Japanese beetle (*Popillia japonica* Newm.). Many observations and experiments have therefore been conducted in the vicinity of Moorestown, N. J., both in the field and in the insectary, to determine what relationship, if any, exists between ants (Formicidæ) and the Japanese beetle or its established parasites in the field.

Observations and diggings of the common ants, chiefly those frequenting habitats favorable to the various stages of *Popillia japonica* in this area, are recorded herein.

OBSERVATIONS OF ANT COLONIES IN 1933

In 1933 diggings were made in and near certain ant colonies in grub-infested areas in late summer and early fall to determine the grub population within the colony itself as well as in the area immediately surrounding such colonies. In general the grub population within the colonies was about the same as that near the colonies, although in some cases more grubs were found in the colony. The following detailed account of three large colonies examined in 1933 will give the reader a true picture of an average ant community in pastures of this area.

¹ The ants used in this study were identified by M. R. Smith, C. F. W. Muesebeck, W. M. Mann, and the late W. M. Wheeler. Acknowledgement is given to R. J. Sim, formerly with the Japanese Beetle Laboratory, for assistance in collecting specimens from various points in New Jersey, and to J. L. King for helpful suggestions and counsel in the preparation of this manuscript.

Colony Site G-5 (Hercher's Pasture)

Hercher's pasture, located 3 miles from the Moorestown laboratory, was chosen for these studies because of its nearness to the laboratory and the willingness of the owner to permit the making of periodic surveys. Diggings in this pasture on August 8, 1933, showed the grub population to range from 1 to 32 per square foot, and according to seasonal surveys the average population for August 1933 was 9 per square foot. In the 18-square-foot area covered by this colony the average grub population was 12.2 per square foot. Grub populations in 10 diggings at random within a 25-foot radius of this infested area, but containing no ants, were as follows: 2, 8, 12, 16, 1, 8, 5, 11, 9, and 6 per square foot, or an average of 7.8 per square foot.

The species of ants in the main colony chosen was *Formica pallide-fulva schaufussi* var. *incerta* Emery, and small colonies of *Lasius* (*Acanthomyops*) *claviger* (Roger), and *L. niger* var. *americanus* Emery were living within the same area. The main colony of *Formica* covered 1 square foot. Only one entrance was visible, and the *Lasius* colonies were unnoticed until some soil was removed. The *Formica* workers had previously been seen bringing a dead larva of the eastern tent caterpillar (*Malacosoma americana* (F.)) to their formicary, and also a dead adult ground beetle (*Calosoma* sp.). They fed readily on the juices of a freshly killed Japanese beetle grub placed upon their mound, and later dragged it beneath the ground.

Colony Site G-3 (Hercher's Pasture)

This colony, of *Formica fusca* var. *subsericea* Say, was also in Hercher's pasture but 200 yards to the west and on a lower well-sodded area. During the summer the refuse heaps were examined and elytra of various Coleoptera, including one Japanese beetle, were found. Japanese beetle grubs were found at the edge of this colony throughout the summer. Diggings within the colony were limited during the summer, as the colony was under observation for feeding habits and general activities. On June 6, however, a small clump of grass within the colony boundary was removed very carefully, and one grub was found among the roots just beneath the surface. Ants were comparatively numerous

here, and when the grub was exposed they attacked it eagerly. Within one-half hour they had dragged the much weakened grub into an entrance, and ant activity again quieted down to normal.

Freshly killed grubs were placed directly upon the mound as well as very near to it. The body walls of some had previously been punctured to allow the body fluids to exude, and in such cases the ants would swarm over the remains, first feeding upon the contents and then dragging the remains into an entrance hole. The unpunctured cadavers were unmolested until foraging workers later chanced upon them and dragged them within their formicary.

When a living grub was placed upon the surface of the mound or at the edge where ants were continually passing, it was attacked by these ants and taken into their formicary. If, on the other hand, the grub was placed barely beneath the surface of the soil, it remained unmolested.

On July 14 at the colony site a living Japanese beetle was observed in combat with several ants. The beetle alighted upon the bare ground, where two ants immediately offered battle, and for half an hour a struggle was carried on during which other ants were attracted to the scene. The beetle was finally overpowered and dragged into the entrance.

On July 18 a section of the colony was excavated, revealing a Japanese beetle pupa. This pupa had been unmolested by the ants, although egg galleries and runaways formed a network around it. As soon as it was disturbed, however, ants immediately attacked and carried it away. In another section of this colony three Japanese beetle larvæ were found unharmed just below the surface. Three were also found at the edge of the main colony area. A dead Japanese beetle was also found within the colony and may have been the one observed 4 days previously.

On September 11 the remainder of this colony was examined. Systematic diggings extended 4 feet to the north and to the south of the area of concentrated activity. The colony area was shaded at times during each day by two trees growing nearby. The area at the south, being covered by shorter grass than that at the north, was more attractive to the beetles for oviposition, and consequently grub population was denser. The total area dug in this colony was 52 square feet and contained 139 grubs, or an

average of 2.6 per square foot. In the central area, where the ants were consistently most numerous, the grub population averaged 1.5 per square foot, while in the bordering bare-ground area, where fewer ants existed, only 1 grub was found per square foot, probably because bare ground is unfavorable for oviposition. If the ants had molested them, there would have been fewer grubs within the colony than in the adjacent area with identical ground cover.

Colony Site S (Haddonfield Pasture)

This colony was in a pasture near the Tavistock Golf Course, Haddonfield, N. J. It was on a sodded knoll, the surrounding area sloping toward a swamp. The ants comprising this colony were the common *Lasius* (*A.*) *claviger*, and were hidden completely by an old burlap bag, beneath which the ground was entirely devoid of vegetation. When examination of this colony was begun, on November 1, 1933, thousands of winged males and females were present. The area not covered by the bag was densely sodded, and because this species was more or less hypogeal, its presence was not evident. Diggings showed these ants to be established over an area of approximately 8 square feet. Grubs in this area averaged 3 to a square foot, whereas the average in a 17-square-foot area immediately surrounding was only 2.6 per square foot. Additional diggings at random around the periphery of this colony and not more than 20 feet from the colony center showed an average of 1.3 beetles per square foot. The observations made in the course of these diggings further exemplify the negative effect of this species upon grubs in the soil.

FIELD SURVEYS IN 1934 AND 1935

In 1934 surveys were continued in areas infested with ants and corresponding areas not thus infested. The data in Table 1 show that in 35 separate diggings of 1 square foot each a total of 210 grubs, or an average of 6 per square foot, was found where no ants were present, while in the same number of diggings of the same size and in the same localities with various species of ants present there was a total of 213 grubs, or 6.1 per square foot. These surveys indicate rather conclusively that at least these species of ants had no ill effect upon grubs present in the soil.

TABLE 1.—Field surveys of populations of Japanese beetle grubs in areas in New Jersey infested with ants and in surrounding uninfested areas, 1934

Date and location of digging		Grubs per square foot in areas—	
		With ants	With- out ants
September 18:			
Vincentown cemetery	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 8 3 4 5 4	{ 6 7 5 9 0
Vincentown pasture	<i>Pheidole pilifera</i> (Roger) <i>Pheidole vinelandica</i> Forel	{ 4 3	{ 3 2
September 19:			
Vincentown pasture	<i>Lasius niger</i> var. <i>neoniger</i> Emery	{ 7 3 4 11 9	{ 4 5 7 10 9
Vincentown roadside	<i>Aphænogaster fulva</i> subsp. <i>aquia</i> (Buckley)	{ 7 7 5	{ 7 2 2
September 26:			
Pemberton pasture	<i>Lasius</i> (<i>Acanthomyops</i>) <i>claviger</i> (Roger)	{ 4 0 2 1	{ 0 1 0 4
	<i>Formica pallide-fulva</i> subsp. <i>schaufussi</i> var. <i>incerta</i> Emery	{ 27 21	{ 31 16
September 27:			
Pemberton pasture	<i>Lasius niger</i> var. <i>neoniger</i> Emery	{ 24 25 1 3 4 1	{ 27 26 3 2 7 0
Pemberton orchard	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 3 4 1	{ 2 7 0
October 3:			
Haddonfield pasture	<i>Myrmica</i> group	{ 2 1 3 0	{ 0 1 0 2
October 4:			
Haddonfield pasture	<i>Lasius</i> (<i>Acanthomyops</i>) <i>claviger</i> (Roger)	{ 2 0 3 5	{ 4 0 2 6
Total		213	210

During June and July 1935, 42 colonies of ants were examined as well as corresponding areas containing no ants. Table 2 gives data obtained from these surveys. In both the areas containing ants and in corresponding check areas the average grub population was 4.3 per square foot. Although this was less than the population in 1934, it seems evident from these surveys that the ants had no ill effect on the grub population.

ESTABLISHED BEETLE PARASITES IN RELATION TO ANTS

EFFECT OF ANTS ON ADULT TIPHIA

Ants are frequently seen foraging in the field on blossoms of wild carrot (*Daucus carota* L.) and on the leaves of maple trees (*Acer* spp.). *Tiphia popilliavora* Roh. obtains nectar from the former and *T. vernalis* Roh. feeds upon the honeydew found on the latter. Twice during the 1934 season the writer witnessed conflicts between *T. popilliavora* adults and the common black ant *Formica fusca* var. *subsericea*. In each case a single ant had obtained a firm hold on a female *Tiphia* and both fell helplessly to the ground. In one case the *Tiphia* gained her freedom as they struck the ground, but in the other the ant retained its hold and, after several minutes of fierce battling, with the aid of two other worker ants carried the *Tiphia* to the formicary. Her wings became very badly damaged before she was finally lost to sight.

In May 1934 a battle between individuals of the same species of ant and a pair of *Tiphia vernalis* adults was observed at Philmont, Pa. This male and female were mating on a maple leaf directly over a mound of these ants, when they suddenly fell to the ground, landing in the midst of ant activity, where they were instantly seized by workers. During the melee the male escaped, but the less fortunate female was injured and dragged within the formicary, where presumably she succumbed.

Since *Tiphia* adults spend considerable time in the soil and on low grass above the soil, ants probably cause the death of some. One such instance was observed at the Overbrook Golf Course in May 1934, while the author was collecting *Tiphia* for colonization. A female was just emerging from the soil, presumably to feed on honey solution sprayed on foliage nearby. Several foraging ants of *Formica fusca* var. *subsericea* were present, and a

TABLE 2.—Field surveys of populations of Japanese beetle grubs in areas in New Jersey infested with ants and in surrounding uninfested areas, 1935

Month and location of digging	Species of ant found	Grubs per square foot in areas	
		With ants	Without ants
June:			
Hercher's pasture	<i>Formica pallide-fulva</i> subsp. <i>nitidiventris</i> Emery	{ 9	11
		{ 7	6
		{ 3	8
	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 11	4
Vincentown pasture	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 9	14
		{ 10	11
		{ 4	4
	<i>Pheidole pilifera</i> (Roger)	{ 2	3
	<i>Lasius niger</i> var. <i>neoniger</i> Emery	{ 5	3
Marlton pasture	<i>Lasius niger</i> var. <i>neoniger</i> Emery	{ 8	7
	<i>Lasius (Acanthomyops) claviger</i> (Roger)	{ 5	6
	<i>Tetramorium caespitum</i> (L.)	{ 6	9
Moorestown roadside	<i>Aphaenogaster fulva</i> subsp. <i>aquia</i> (Buckley)	{ 3	1
	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 3	4
		{ 3	3
Spring Hill Country Club, Lenola	<i>Formica pallide-fulva</i> subsp. <i>nitidiventris</i> Emery	2	2
	<i>Tetramorium caespitum</i> (L.)	4	5
	<i>Lasius (Acanthomyops) interjectus</i> Mayr	0	1
Haddonfield pasture	Myrmica group	{ 9	8
	<i>Formica pallide-fulva schanfussi</i> var. <i>incerta</i> Emery	{ 0	0
		{ 4	11
	<i>Formica fusca</i> var. <i>subsericea</i> Say	{ 5	2
		6	1

TABLE 2—(Continued)

Month and location of digging	Species of ant found	Grubs per square foot in areas	
		With ants	Without ants
June, cont.:			
Medford pasture	<i>Lasius (Acanthomyops) claviger</i> (Roger)	{ 4	4
	<i>Lasius niger</i> var. <i>neoniger</i> Emery	{ 7	5
	<i>Lasius (Acanthomyops) interjectus</i> Mayr	3	5
	<i>Formica fusca</i> var. <i>subsericea</i> Say	4	2
	<i>Solenopsis molesta</i> (Say)	13	9
Woodbury Golf Course	<i>Solenopsis molesta</i> (Say)	2	4
	<i>Prenolepis imparis</i> (Say)	0	2
July:			
Hercher's pasture	<i>Formica pallide-fulva schaufussi</i> var. <i>incerta</i> Emery	3(+1 beetle)	0
	<i>Solenopsis molesta</i> (Say)	{ 2 1(+1 Phyl. grub)	2 2(+1 beetle)
		{ 0	2(+1 beetle)
	<i>Lasius (Acanthomyops) claviger</i> (Roger)	{ 3 0	3 2
		{ 2 3(+4 beetles)	1 beetle 4(+2 beetles)
<i>Formica fusca</i> var. <i>subsericea</i> Say		{ 1	1
	<i>Formica pallide-fulva schaufussi</i> var. <i>incerta</i> Emery and <i>Solenopsis molesta</i> (Say)	3(+1 beetle)	0
	<i>Lasius niger</i> var. <i>americanus</i> Emery	3	2(+1 beetle and 2 eggs)
Total		180	180

fierce battle ensued in which the wings of the *Tiphia* became damaged, preventing her flight and enabling the ants to drag her into their nest without further opposition. Incidents of this type are exceedingly interesting to watch and may happen rather frequently, but are probably of little economic importance.

EFFECT OF ANTS ON TIPHIA COCOONS

An instance of damage to *Tiphia* cocoons in the field by *Solenopsis molesta* was observed in 1932, when several cocoons held in vials stoppered with fine wire screens and buried in the soil were riddled. These tiny yellow ants were able to make entrance into the vials through the screen. Again during the following season cocoons buried in a similar manner were destroyed.

Cocoons formed naturally in the field have also been found completely riddled with holes, and frequently the same species of ant has been associated with them. Material held in the insectary has sometimes been attacked by this ant, as will be reported under "Insectary Experiments." If colonies of *Solenopsis molesta* were more numerous in the Moorestown area, they might easily prove an important factor working against parasite establishment and subsequent increase.

EFFECT OF ANTS ON PARASITIZED GRUBS

No evidence has come to the writer's attention of ants molesting parasitized grubs in the field. It seems entirely plausible, however, that some such helpless individuals should fall prey to these industrious workers. This seems especially probable at times of advanced parasitization by certain dipterous parasites, and just prior to cocoon formation in case of hymenopterous parasites. At such times the parasitized grub lies helpless, and this as well as the parasite larva itself should be appetizing food for many ants, which often are none too particular in their choice of viands.

EFFECT OF ANTS ON FLY PUPARIA

In one colony of *Formica fusca* var. *subsericea* the remains of a *Phyllophaga* adult containing a fly puparium were found. This aroused suspicion that certain Japanese beetles containing puparia of *Centeter cinerea* Ald. might be destroyed by foraging

ants, especially since a large proportion of beetles parasitized by this fly crawl beneath dead leaves and trash to die. These places are favorite hunting grounds for many ants, and such beetles may fall victims of rapacious individuals oftener than is supposed. Observations have not materially strengthened this supposition although in 1935 one beetle bearing a *Centeter* egg was found in a colony of *F. fusca* var. *subsericea*. In areas of heavy parasitization by *C. cinerea* instances of this nature might be of significance.

INSECTARY EXPERIMENTS

SPECIES OF ANTS STUDIED

Twenty-three of the most common species (or varieties) of ants, found in this area, representing 11 genera, were used in extensive insectary experiments to determine if any relationship exists between Formicidæ and *Popillia japonica*. The following species were included:

Formica pallide-fulva subsp. *schaufussi* var. *incerta* Emery

Formica fusca var. *subsericea* Say

Formica fusca var. *subænescens* Emery

Formica sanguinea subsp. *rubicunda* Emery

Formica truncicola subsp. *integra* Nylander

Formica sanguinea subsp. *subintegra* Emery

Formica neogagates Emery

Formica pallide-fulva subsp. *nitidiventris* Emery

Solenopsis molesta (Say)

Lasius (Acanthomyops) claviger (Roger)

Lasius (Acanthomyops) interjectus Mayr

Lasius niger var. *americanus* Emery

Lasius niger var. *neoniger* Emery

Pheidole morrisi Forel

Pheidole pilifera (Roger)

Pheidole vinelandica Forel

Crematogaster lineolata var. *cerasi* (Fitch)

Tetramorium cæspitum (L.)

Tapinoma sessile (Say)

Monomorium minimum (Buckley)

Prenolepis imparis (Say)

Aphanogaster fulva subsp. *aquia* (Buckley)

Myrmica scabrinodis group

EXPERIMENTAL PROCEDURE

Two types of cages were used in this work and are hereafter spoken of as large cages and small cages. The former type was a wooden box 1 foot square by 2 feet deep. The upper 6 inches on two sides was of glass instead of wood, permitting observation of ant activity within the cage. The top was hinged and consisted of wire screen of very fine mesh, assuring ample ventilation and entrance of necessary moisture. All wooden parts of the cage were soaked in paraffin to prevent excessive decay when buried. In the bottom several holes 1 inch in diameter were bored and covered with wire screen similar to that used on the top, to permit the entrance and escape of moisture. Further to facilitate drainage, in some of the cages long slits were made in the sides and likewise covered with screen. However, cages without such slits remained in as good condition as the others, and in excessively wet periods were in even better condition. During such wet weather boards were placed over the cages.

These cages were buried in the soil to a depth of $1\frac{1}{2}$ feet, the glass sides remaining above ground. Grass or wheat was planted in the cages before the ants and grubs were placed there. Both crops grow well and sometimes need to be cut back to prevent undue shading of the ground. Dry leaves and a medium-sized flat rock were also placed in each cage, as many ants prefer their formicary beneath shelter, at least at the start, and hypogæic species remain almost entirely under cover.

The small type of cage consisted of two plates of common window glass placed on a vertical frame so that there was a solid bottom and a half-inch space between the plates to hold soil. A cover consisting of a wedge-shaped piece of wood retained the ants. By the use of glass sides ant activity was readily observed without disturbing the enclosed individuals. It was found advantageous to darken one side of the cage with a black cloth or heavy paper. Runways were well distributed throughout the soil, but the ants always reared their young and congregated in galleries on the darkened side.

The small cages can be kept at room temperature and ant activity maintained throughout the year. Moisture must be added every 5 or 6 weeks during the winter or in cool spring and fall

weather and at intervals of 2 to 3 weeks in the summer. Ants confined in these cages for 3 months have been removed seemingly in as vigorous condition as when first placed within. The ordinary time of confinement, however, was approximately 30 days. If ants confined in these small cages for 30 days with grubs do not molest them, it is doubtful that they would if left longer. Most species, unless very small, will tunnel throughout the soil within the first week, but some never penetrate to any great depth.

Ants and grubs were placed in each of a series of these small cages, and in some the ants were fed a candy made of white sugar and honey, whereas in others they were not fed during their confinement. The ants that were fed lived longer and were kept alive indefinitely by feeding. The absence of food did not seem to force their attentions upon the grubs but merely shortened their lives.

RESULTS

Accumulated data obtained from the numerous experiments conducted in the insectary show that 54 cages containing ants had at the time of examination at least as many grubs as the corresponding check cages without ants. Of 901 grubs placed in the cages, only 428 were accounted for after 30 days in the cages containing ants and grubs, with 36 of this number being dead. In the corresponding check cages without ants, after the same number of days and receiving the same treatment, 487 of the 901 grubs were accounted for, of which 75 were dead. In other words, 39 more dead grubs were found in cages without ants than in cages containing ants, and likewise 59 more living forms occurred in the checks than in the cages containing ants. A very slight indication of the destruction of dead remains by ants seems evident from these data, which would be of little consequence unless such remains were diseased.

In experiments in which eggs of *Popillia japonica* were placed in the soil and left for development, a total of 270 was used in experiments with ants and a corresponding number in cages without ants. A total of 102 first- and second-instar grubs was found in the cages with ants, whereas 105 grubs in the same stages were found in the cages without ants at the time of examination.

From this small difference one cannot attribute serious effects by the ants on the eggs or on the first and second instars.

In many of the cages some of the third-instar grubs became adults during the course of the experiments, thus exposing at some time the helpless prepupal and pupal stages. Ants, however, paid no more attention to these than to the more active stages.

DAMAGE TO *TIPHIA* COCOONS

Damage by ants to *Tiphia* cocoons being held for development has sometimes been reported. Such an instance was brought to the attention of the author in 1934, when several cocoons held in rearing trays were riddled with holes and their contents eaten by the small yellow ant *Solenopsis molesta*. These trays are divided into small compartments, and one parasitized larva is placed in each section before it is filled with soil. The trays are then stacked and held for development of the parasite larva and subsequent cocoon formation. Sometimes grubs in these trays come to the surface of the soil, and on one occasion an individual confined within a compartment was observed to be overcome by myriads of these ants. *Solenopsis molesta* is supposedly fond of fats and greases, but the writer was successful in attracting them to a sponge saturated with honey.

Owing to the slight indication noted in field studies that *Tiphia* cocoons are occasionally riddled by ants, as well as to similar observations in the insectary, further tests were made of such tendencies. Both the small and the large types of cages used in other experiments were tried. In each of the smaller cages, on October 3, 1934, six parasitized grubs were placed in the soil with ants, and corresponding check cages were set up without ants. Development continued, and cocoons were visible on October 25. In all cages after 3 months the ants were as active as when first placed within, and in almost every case had tunneled throughout the soil. Daily observations of several cocoons that were visible failed to indicate any damage, although the ants had runways throughout the soil and one cocoon was in their direct path for 2 months. When the soil was removed on February 15, 1935, only one cage containing individuals of *Lasius* (*Acanthomyops*) *claviger* gave evidence of possible damage to cocoons. In similar later experiments with this species no interference resulted.

Thirty-seven parasitized grubs were placed in each of 12 large cages and allowed to form cocoons in the presence of ant colonies. Four species of ants were used in these tests, namely, *Lasius* (*Acanthomyops*) *claviger*, an ant of the *Myrmica scabrinodis* group, *Pheidole morrissi*, and *Tetramorium cæspitum*. Equal numbers of parasitized grubs were used in similar cages without ants. These cages were buried outdoors in October 1934 and left undisturbed until April 1935, at which time they were examined for cocoons. Three hundred and twenty-nine cocoons were found both in the cages containing ants and in the checks without ants, and none of these was damaged. This was 74 per cent of the total number of parasitized grubs used and indicates a negative effect of at least these species upon parasitized larvæ or the resultant cocoons.

Since *Solenopsis molesta* had shown a tendency to molest *Tiphia* cocoons, individuals were collected for insectary experiments with this species. Several cocoon cells of copper screening were placed in soil in cages containing these ants. The mesh of this screen was coarse enough to permit entrance of ants but too fine to allow soil to sift through readily. These cocoons remained in good condition and after 2½ months only 1 out of 25 showed signs of fungus. Twenty per cent of these cocoons were riddled by this tiny ant, showing that the species might easily become a serious factor working against *Tiphia* establishment and subsequent increase. Fortunately, however, these ants were not generally abundant in areas containing cocoons.

DAMAGE TO OTHER POPILLIA JAPONICA PARASITES IN THE INSECTARY

One instance of damage to insectary material other than *Tiphia* cocoons was noted in 1932, when ants of the species *Solenopsis molesta* ruined a portion of an experiment by killing flies of *Prosenia sibirita* (F.) that were being held in a small cloth cage. The ants were no doubt attracted to the cage by honey which was sprayed daily upon leaves as food for the flies. After having been attracted to the scene, they played havoc with the flies as they larviposited upon the soil.

SUMMARY

To obtain information on the part played by ants (Formicidæ) in the destruction of the Japanese beetle (*Popillia japonica* Newm.) and its parasites, observations have been made of the ants occurring in the Moorestown, N. J., area, and 23 species, representing 11 genera, found to be most common have been studied in the insectary.

Ants have been observed attacking living larvæ as well as adult beetles in the field.

Comparative data from field surveys in areas infested with ants show very little difference in grub population.

Results of numerous insectary experiments testing any possible relationship existing between ants and the Japanese beetle seem to indicate little, if any, harm by the 23 species tried, either to the egg or to any subsequent stage.

Formica fusca var. *subsericea* Say was observed overpowering adult *Tiphia* in the field.

Experiments dealing with various formicid species and *Tiphia* cocoons in the soil show only one species, *Solenopsis molesta* (Say), to damage cocoons consistently. Cocoons riddled by these tiny workers have been found in the field as well as in the insectary.

A single record is given of the finding within a colony of *Formica fusca* var. *subsericea* of a beetle containing a *Centeter cinerea* egg, and of another containing a fly puparium.

NOTICE TO AUTHORS

Authors whose papers, in past years, were illustrated by line-cuts or half-tones, may obtain such cuts, insofar as they are still in existence, by defraying in advance the cost of packing and shipping them. If claims for such plates are not made within six months after the appearance of this notice, the Society reserves the right to destroy unclaimed plates. Correspondence should be addressed to the Secretary of the New York Entomological Society.

BOOK NOTICE

The Principles of Insect Physiology. By V. B. Wigglesworth, M.A., M.D., F.R.S. Reader in Entomology in the London School of Hygiene and Tropical Medicine. Large 8vo., cloth, 434 pp., 316 illus., New York. E. P. Dutton & Co., 1939, \$8.00.

This book is of general monographic character, in which particular emphasis has been given to the functions of organs and tissues, and it has been so prepared as to amplify and supplement other recently issued works on entomology, notably, those by Immes, Weber, Snodgrass and others, in which books primary emphasis has been given by their authors on diversity of form. Its subdivisions include discussions of such matters as development of the egg; growth; muscular system and locomotion; nervous system; sense organs; vision; mechanical and chemical senses; behavior; respiration; circulatory system and associated tissues; digestion and nutrition; excretion; metabolism; temperature relations, and the like. In its preparation special care has been used to make it particularly suitable to the needs of students of general entomology, of insect ecologists, and of economic entomologists. Fully illustrated and well documented with a wide range of bibliographical reference for those who desire to delve further into various ramifications of the subject, this work, though primarily on physiology, will be of helpfulness in enabling its readers to obtain a grasp of the broad basic principles underlying the ecology and practical control of insect pests.—J. S. W.

A German-English Science Dictionary for Students in the Agricultural, Biological and Physical Sciences. By Louis DeVries, Professor of Modern Language, Iowa State College, with collaboration of members of the Graduate Faculty. 12mo., semi-flexible cloth, 473 pp., N. Y., McGraw-Hill Book Co., 1939, \$3.00.

The little book contains 48,000 terms (German-English) pertaining to the agricultural, biological and physical sciences: bacteriology, medicine; botany and zoology (including anatomy, embryology, pathology and physiology), entomology, genetics, forestry, horticulture, agronomy, chemistry, physics, and mathematics. Many common idioms and other terms likely to be needed by students are included and past tenses and past participles are translated for the benefit of elementary students. A noteworthy feature is a list of references to other similar works, over fifty in number, including general dictionaries, German-English scientific dictionaries and glossaries. Originating at Iowa State College through the development of complicated inter-departmental research problems, this book has been in preparation for some 25 years and is, to a degree, the composite work of 34 members of the Graduate Faculty of that institution. It has been prepared to meet a definite need for a comprehensive work effectively adjusted to the steadily increasing overlapping of the sciences. The small size, the semi-flexible binding, and the ease with which it lies open, all make it more readily portable and convenient to use. An exceedingly appropriate quotation for a work of this type appears opposite the title page and was taken from Dr. Samuel Johnson: "Every other author may aspire to praise, the lexicographer can only hope to escape reproach."—J. S. W.

The World of Insects. By Carl R. Duncan and Gayle Pickwell. 8vo., cloth, 409 p., 194 Figs. New York, McGraw-Hill Book Co., 1939. \$3.50.

Written by a professor of entomology and botany and a professor of zoology respectively in the San Jose (Calif.) State College, this book is another brief, non-technical resume of the type of information usually presented in the numerous works of

this kind which have appeared in recent years. Consideration is given to such topics as insect structure and growth; food and feeding habits; insect voices; social life among the insects; collecting and rearing insects; book lists for further study, and the like. Some of the material here presented originally was issued in publications of the San Jose Teacher's College. It has, however, been extensively revised; many new sections and one new chapter as well as many new illustrations have been added. Practically all the photographs were taken by the junior author, and many of these are of considerable excellence.—J. S. W.

Of Ants and Men. By Caryl P. Haskins. Research Associate, Harvard University. 8vo., cloth, 244 p., 15 illus. New York, Prentice-Hall Inc., 1939. \$2.75.

In this book the author undertakes to make a brief review of the origin and evolution of ants. Further, the author treats of their concerted behavior in so far as it illustrates some of the similarities and some of the differences which exist between their social life and that of ourselves. The data assembled and presented form excellent exemplifications of the truism that, almost inevitably, any group of animals and plants, which superficially may appear a most compact and homogeneous unit, will upon minute examination be found to contain the widest diversification in membership. Some of these similarities and dissimilarities are here discussed in detail, while others are given scarcely more than mere mention. Against a well developed background, man is brought into spotlight. The author holds no halo over his head either from the standpoint of the present time or from the background of the past. He does, however, have confidence in humanity in dealing with the problems of existence or, as Thoreau would put it: "There is more day to dawn." Since this volume is one of selections of the Scientific Book Club, it is probable that it will find its way into the library both of the serious scientific worker and the dilettante. Fortunately, any one can read this little book with pleasure and profit, and the more the reader already knows about ants and about men, the keener will be the enjoyment of it.—J. S. W.

NOTICE TO MEMBERS

The Society has on hand a large stock of loose "signatures" (not separates) of volumes 14 to 31 inclusive, of the Journal in addition to the regular stock of "numbers." These will be distributed free to members upon request to the Librarian as long as the supply lasts, if the requests are received before May first. Lists of desiderata *must* list the exact pages desired *and* each plate desired, by number. Requests will be filled in the order received and the parts will be mailed early in May. Address requests to R. E. Blackwelder, American Museum of Natural History, New York, N. Y.

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No. 2

RECORDS AND DESCRIPTIONS OF NEOTROPICAL CRANE-FLIES (TIPULIDÆ, DIPTERA), XI

BY CHARLES P. ALEXANDER

AMHERST, MASSACHUSETTS

The preceding instalment under this title was published in September, 1938 (JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY, 46: 327-337). The crane-flies described at this time are from Potrerillos, "The Valley of the Clouds," in Chiriqui, northern Panama, where they were collected by Mr. D. V. Brown, February to May 1934, and Mr. J. W. MacSwain, May to June 1935. My deep thanks are extended to the collectors of this rich material. All types are preserved in my private collection of the Tipulidæ of the World. Only a portion of the novelties are described at this time, the entire collection being rich and varied in species.

Genus *Tipula* Linnæus

Subgenus **Neotipula** new.

Frontal prolongation of head slender; nasus elongate. Antennæ 13-segmented; flagellar segments three to nine, inclusive, with a conspicuous lobe on distal half, this lobe exceeding one-half the length of the segment and producing a weak pectinated appearance; setæ of flagellum reduced, restricted to a series on outer face of segment on opposite side from the pectination; no basal enlargement on any of the segments; verticils lacking; terminal segment elongate, subequal in length to the penultimate. Tibial spur formula 1-1-2; claws large, each with an obtuse lobe before midlength. Sternopleural setæ sparse, small and pale. Wings with squama naked; veins unusually glabrous, beyond cord including a very restricted series of tiny trichia on vein R_{4+5} . Venation: Rs shorter than $m-cu$; R_2 before fork of R_{3+4} ; veins R_3 and R_{4+5} nearly straight, not sinuous at near midlength, as in

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Holorusia, cell R_3 consequently not constricted at this point; vein M conspicuously arched before fork; $m-cu$ long, cell M_4 unusually wide, at margin only a little shorter than cells M_1 to M_3 combined.

Type of subgenus.—*Tipula* (*Neotipula*) *pectinella* new species. (Neotropical Region).

Besides the subgenotype, it would appear that *Tipula maya* Alexander likewise belongs here. The strict affinities are very uncertain. The nature of the antennæ, as the lack of a basal enlargement and accompanying verticils on the flagellar segments, is more suggestive of *Holorusia* than of *Tipula* but the venation of the radial field precludes its reference to the former genus. I prefer to consider it as being more closely related to *Tipula* while emphasizing these points of difference. It seems entirely possible that the group will eventually be elevated to full generic rank.

***Tipula* (*Neotipula*) *pectinella* new species.**

Size large (wing over 35 mm.); general coloration of notum reddish brown, the scutum behind traversed by a blackened band; pleura yellow, with a narrow dorso-longitudinal brown stripe; halteres brownish black, the knobs obscure yellow; legs brownish yellow, the femora with tips broadly blackened, preceded by a slightly narrower pale yellow ring; wings with a rich brown suffusion, variegated by sparse darker brown and more abundant cream-colored areas; R_2 shortly before fork of R_{3+4} ; abdominal tergites dark reddish brown, with narrow, more blackish stripes.

MALE.—Length about 30 mm.; wing 36 mm.; antenna about 4 mm.

Frontal prolongation of head and the palpi black. Antennæ dark brown, the first flagellar segment paler; structure as above described. Head dark brown, the posterior orbits dull yellow; anterior vertex relatively narrow, about one-half wider than the diameter of the scape.

Pronotum yellow, narrowly darkened on median border. Mesonotal præscutum with the ground-color obscure yellow, almost covered by four reddish brown stripes, the sublateral portions of the sclerite deepening to black, the extreme border yellow; scutum with median area obscure yellow, the lobes reddish brown, the entire distal fourth of scutum traversed by a blackened band; scutellum dark gray, parascutella brown, the cephalic and caudal portions yellow; mediotergite plumbeous gray, the posterior and lateral portions broadly brownish black. Pleura yellow, with a narrow, dark brown, longitudinal stripe extending from the cervical margin across the dorsal pleurites, passing through the anterior spiracle, ending at wing-root. Halteres long, brownish black, the extreme base of stem and apex of knob obscure yellow. Legs with the coxæ and trochanters yellow; femora brownish yellow, darker outwardly, the tips broadly blackened, preceded by a

slightly narrower pale yellow ring; tibiae light brown, the bases more whitened, the tips narrowly infuscated; tarsi light brownish yellow. Wings with a strong rich brown suffusion, sparsely variegated by darker brown and more numerous cream-colored areas; the chief dark spot lies at near two-thirds the length of cell *M*; the cream-colored areas occupy cell *M* before and beyond the dark spot, across the cubital and anal cells, and in the outer medial field; cell *Sc* uniformly dark brown; veins reddish brown, the obliterative areas at cord small but conspicuous. Venation: Petiole of cell *M*₁ a little longer than *m*; cell 2nd *A* wide.

Abdominal tergites dark reddish brown, with three narrow blackish stripes that are more or less interrupted at the posterior borders of the segments, especially the median stripe; basal tergite brightened medially; extreme caudal margins of segments pale; sternites more uniformly reddish brown; hypopygium a little brightened. Male hypopygium with the eighth sternite conspicuously produced beyond the level of remainder of hypopygium.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 20, 1935 (MacSwain).

The most similar species seems to be *Tipula maya* Alexander, of Guatemala, still known only from the unique female type in which the antennae were broken. The essentials of venation of the two species are very similar and it seems certain that *maya* will likewise be found to belong to this new group.

***Tipula browniana* new species.**

Belongs to the *glaphyroptera* group; general coloration yellow, the præscutum with four pale brown stripes, the intermediate pair irregular, broken before midlength, behind this point closely approximated or fused; antennae short, bicolored; halteres yellow; femora brownish yellow, with a narrow pale brown subterminal ring, preceded by a clearer yellow annulus; wings light yellow, with a tessellated brown pattern; *R*₁₊₂ entire; *Rs* long; abdomen yellow, the basal tergites narrowly lined sublaterally with dark; male hypopygium with a small median lobe in membrane between eighth and ninth sternites, this bearing long conspicuous setae.

MALE.—Length about 13 mm.; wing 14 mm.; antenna about 3 mm.

Frontal prolongation of head yellow; nasus distinct; palpi with basal three segments yellow, the terminal segment dark brown. Antennae relatively short, if bent backward extending about to wing-root; basal three segments light yellow, the remainder of flagellum bicolored, yellow, with the small basal enlargements abruptly black; verticils a little longer than the segments. Head obscure yellow; posterior orbits and a slight cloud on anterior vertex pale brown; anterior vertex relatively wide, approximately five times the diameter of scape; vertical tubercle low, its cephalic end very feebly notched.

Pronotum yellow, faintly darkened medially above. Mesonotal præscutum

yellow with four pale brown stripes; intermediate stripes irregular in outline, on cephalic third of sclerite widely separated, slightly broken at this point and thence forming a single median stripe to the suture; lateral stripes narrow, the margins laterad of these stripes less evidently darkened; scutum yellow, the lobes and a narrow but conspicuous median vitta pale brown; scutellum broadly pale yellow, the parascutella darker; mediotergite yellow, with a broad, conspicuous, pale brown, median line. Pleura yellow, the dorsopleural region a little darker; pleurotergite weakly infumated. Halteres pale yellow. Legs with the coxæ and trochanters yellow; femora brownish yellow, the bases clearer yellow, with a narrow pale brown subterminal ring, preceded by a much wider, clearer yellow annulus; tibiæ yellow, the tips weakly infumated; tarsi yellow, the outer segments brown. Wings light yellow, the costal and prearcular fields more saturated yellow; a conspicuous tessellated pale brown pattern, as follows: Four subcostal areas, the first postarcular, including bases of cells *R* and *M*; second area at about one-third the length of cell *R*, reaching vein *M* behind; third area at origin of *Rs*, not reaching *M*; fourth area stigmal, confluent with a major darkening on anterior cord; remaining cells of wing with zigzag brown clouds, subequal in extent to the yellow ground; outer half of cell *R*₅ and most of *M*₃ uniformly pale; veins yellow, infuscated in the clouded areas. Venation: *R*₁₊₂ pale but entire; *Rs* long, about two and one-half times *m-cu*; petiole of cell *M*₁ subequal to *m*.

Abdomen yellow, the basal tergite narrowly lined laterally with darker; hypopygium yellow. Male hypopygium with the ninth tergite transverse, the caudal margin crenulate, with a very shallow U-shaped median notch; dorsal surface of tergite with a median furrow. Outer dististyle relatively long, narrowed on basal third, sinuous. Inner dististyle relatively broad, the posterior angle at base rounded. Basistyle produced into a setiferous lobe, its dorsal angle prolonged into a conical spine immediately behind the insertion of the inner dististyle. Membrane between eighth and ninth sternite with a small subglobular or short-oval median lobe that bears more than a score of very long strong setæ.

Holotype, ♂, Potrerillos, altitude 3,500 feet, May 12, 1934 (Brown).

Tipula browniana is named in honor of the collector, Mr. D. V. Brown. The species most resembles forms such as *T. absona* Alexander, of Ecuador, and allies, differing especially in the pattern of the mesonotum and wings, and in the structure of the male hypopygium. There are several species of the group having a checkered wing-pattern, these differing among themselves in the presence or absence of vein *R*₁₊₂, the coloration of the femora, the wing-pattern and venation, and in the structure of the male hypopygium.

***Tipula scriptella* new species.**

General coloration of thorax obscure yellow, the præscutum with dark stripes; pleura with a complete dark brown girdle on mesepisternum; halteres obscure yellow; femora yellow, with a relatively narrow and ill-defined pale brown subterminal ring; wings brown, streaked longitudinally with whitish and variegated with small darker brown areas; abdominal tergites yellow, with three brown stripes, the sternites with a similar median vitta.

FEMALE.—Length about 17 mm.; wing 15 mm.

Head behind obscure yellow, the anterior part destroyed.

Mesonotum obscure yellow pollinose, with dark brown stripes on præscutum; central portion of mediotergite darkened, the sides broadly pale. Pleura obscure yellow, variegated with dark brown, including a complete transverse girdle from lateral margin of præscutum across the dorsopleural membrane, involving most of the mesepisternum; pleurotergite slightly darkened. Halteres obscure yellow. Legs with the coxæ and trochanters yellow; femora yellow, with a relatively narrow and ill-defined pale brown subterminal ring; tibiæ yellow, the tips narrowly darkened; basal two tarsal segments yellow, the tips very narrowly darkened, the outer tarsal segments uniformly brown. Wings with the ground color brown, conspicuously variegated with darker brown and whitish subhyaline, the latter chiefly distributed as a central streak involving the middle third of wing, including cell *1st M*₂ and bases of all outer medial cells, reaching the margin in cell *R*₅; cubital and anal cells likewise extensively whitened; cell *C* uniform medium brown; cell *Sc* with four small dark areas, the second at origin of *Rs*, all but the last involving the radial field behind; cells *R*₃ and *R*₄ chiefly and almost uniformly infumated; darker brown areas at anterior cord, outer end of cell *1st M*₂ and as broad seams on outer half of vein *Cu*, distal section of *Cu*₁ and *m-cu*; outer medial field infumated, with pale marginal droplets in outer ends of cells *2nd M*₂ and *M*₃; veins yellow, darker in the clouded areas. Venation: *R*₁₊₂ entire; *M*₃₊₄ only a little shorter than the basal section of *M*₃.

Abdominal tergites obscure yellow, with three brown stripes, the median one broad on basal and intermediate segments, narrowed on outer tergites, ending on tergite seven, slightly interrupted at the posterior margins of the segments; lateral stripes narrow, becoming obsolete behind; sternites yellow, with a median brown vitta. Ovipositor with cerci nearly straight, very slender.

Holotype, ♀, Potrerillos, altitude 3,500 feet, May 12, 1934 (Brown).

In its general appearance, especially the wing pattern, the present fly is most similar to the Chilean *Tipula philippiana* Alexander, differing in the details of coloration and venation. It is probable that this species will be found to belong to the *glaphyroptera* group of species.

***Tipula ctenopyga* new species.**

General coloration of mesonotum reddish brown, the usual stripes reduced to three conspicuous black spots; antennæ elongate; femora obscure yellow, the tips very narrowly but conspicuously black; wings with a brown tinge, the stigma dark brown, conspicuous; R_{1+2} entire; abdomen with a subterminal black ring; male hypopygium with the conspicuous tergite parallel-sided, the apex convexly rounded and set with abundant black setæ; a conspicuous black lobe on mesal face of basistyle; eighth sternite produced ventrad into scoop-like flattened lobes that bear marginal spinous setæ; ædeagus trifid at apex.

MALE.—Length about 12 mm.; wing 11.5 mm.; antenna about 4.8 mm.

Frontal prolongation of head short and stout, without nasus, obscure brownish yellow; palpi dark brown. Antennæ relatively long; basal three segments obscure yellow, succeeding segments black, the apices very restrictedly brightened; at and beyond midlength of the organ the segments are uniformly black; flagellar segments incised; terminal segment very small. Head chestnut brown; anterior vertex wide.

Mesonotum reddish brown, the præscutum with three black spots, one representing the anterior fourth of a narrow median stripe, the others occupying the anterior ends of the usual outer præscutal stripes, extending laterad to the margins; scutellum and mediotergite darkened. Pleura obscure reddish yellow. Halteres dusky. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips very narrowly but conspicuously black, the amount subequal on all legs; tibiæ obscure brownish yellow, the tips very narrowly blackened; basitarsi brownish yellow, the outer tarsal segments brownish black. Wings with a brown tinge, preareolar region and cells *C* and *Sc* more yellowish; stigma oval, dark brown, conspicuous; veins brownish black, paler in the more brightened costal portions. Wings with conspicuous basal petiole; macrotrichia on veins R_{2+3} , R_3 , R_{4+5} and M_1 , very restricted or lacking elsewhere beyond cord. Venation: R_{1+2} entire; cell 1st M_2 long and narrow; petiole of cell M_1 a little exceeding *m*; cell 2nd *A* very narrow, reduced to a linear strip.

Basal abdominal tergites reddish, with a broken black median stripe, on tergites two and three including the narrow posterior borders; tergites six and seven uniformly black; sternites reddish yellow, segments seven and eight black; hypopygium obscure reddish yellow. Male hypopygium with the ninth tergite unusually long, obliquely elevated, projecting caudad to opposite or beyond the outer level of the dististyles; parallel-sided, the caudal margin gently convex, blackened by an abundant concentration of setæ. Lower and inner face of basistyle with a conspicuous, elongate, black lobe, its margin microscopically roughened. Outer dististyle small, slender, black. Inner dististyle a compact compressed blade. Eighth sternite extensive, the apical portion directed ventrad into two flattened scoop-like lobes, separated from one another by membrane, their margins with several black spinous setæ that pass into longer normal setæ on mesal portions. Aedeagus small and slender, before apex on either side with a slender spinelike arm, presenting the appearance of a delicate trident.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 20, 1935 (MacSwain).

Tipula ctenopyga is most nearly related to *T. detecta* Alexander, of Venezuela, differing in the wing-pattern and venation, and in the coloration of the body and legs. The male sex of *detecta* is still unknown to me.

***Limonia (Limonia) paucilobata* new species.**

Belongs to the *apicata* group; general coloration of mesonotum yellow, the præscutum with a black median stripe and shorter, confluent lateral stripes; pleura chiefly yellow; fore femora black; wings with a strong dusky tinge, the stigma and outer radial field darker; *m-cu* at fork of *M*; abdominal tergites brownish black, the sternites obscure yellow; male hypopygium with basistyle simple, provided with a single lobe.

MALE.—Length about 6 mm.; wings 6.5 mm.

Rostrum and palpi black. Antennæ black throughout; basal flagellar segments oval, the outer segments subcylindrical; segments with short glabrous apical necks; terminal segment longer than penultimate, its outer end pointed. Head gray, clearer gray along posterior orbits and on the linear anterior vertex; central portion of posterior vertex blackened.

Pronotum obscure yellow, narrowly blackened medially. Mesonotal præscutum polished yellow laterally, with a conspicuous entire black median stripe and short confluent lateral stripes; scutal lobes blackened, the median area obscure yellow; scutellum obscure yellowish brown, paler on posterior margin; mediotergite infuscated. Pleura and pleurotergite obscure yellow, the anepisternum and ventral pleurotergite slightly darkened. Halteres dark brown, the base of stem restrictedly yellow. Legs with the coxæ and trochanters yellow; fore femora black, the bases narrowly yellow; middle and posterior femora dark brown, pale basally, the tips passing into black; tibiæ and tarsi brown, the terminal segments of the latter darker. Wings with a strong dusky tinge, the outer radial field more evidently infumated; stigma oval, darker brown; veins dark brown. Venation: *Sc* long, *Sc*₁ ending shortly before fork of *Rs*, *Sc*₂ close to its tip; *Rs* exceeding twice the basal section of *R*₄₊₅; *m-cu* at fork of *M*.

Abdominal tergites brownish black; sternites obscure yellow; hypopygium darkened. Male hypopygium with the basistyle simple, the mesal face on proximal half with a single stout lobe. Dististyle simple, gradually narrowed to a slender curved beaklike point. Gonapophyses unusually broad and flattened, the terminal beak short and curved. Aedeagus narrow.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 5, 1935 (MacSwain).

In the structure of the male hypopygium, *Limonia (Limonia) paucilobata* is quite distinct from the other members of the

apicata group. The relatively simple nature of the basistyle is likewise found in *L. (L.) acuminata* Alexander, *L. (L.) hoffmani* Alexander, *L. (L.) rapax* Alexander, and others, but the details of structure of all parts of the hypopygium are distinct.

Orimarga (Orimarga) melampodia new species.

General coloration gray, the lateral margin of præscutum, together with the pleura, striped longitudinally with blue-gray; legs brownish black; wings whitish subhyaline; *Sc* short, R_{1+2} relatively long, approximately three times R_{2+3} ; abdomen brownish black.

MALE.—Length about 9 mm.; wing 6.5 mm.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with short verticils; terminal segment larger than the penultimate. Head gray.

Mesonotum almost uniform dark plumbeous gray, the lateral margins of præscutum more blue-gray pruinose; a blackened spot on lateral margin of præscutum before suture. Pleura above light gray, with a broad blue-gray stripe extending from behind the fore coxæ, passing above remaining coxæ to base of abdomen, narrowly bordered above by blackish; ventral sternopleurite blackened. Halteres with stem pale yellow, knob dark brown. Legs with coxæ and trochanters black; remainder of legs brownish black, the femoral bases not or scarcely brightened. Wings whitish subhyaline; veins brown. Venation: *Sc* short, Sc_1 ending about opposite one-fifth the length of *Rs* and before level of *m-cu*; R_{1+2} fully three times R_{2+3} and about one-third the length of *Rs*.

Abdomen brownish black, the sternites a little paler. Male hypopygium with the outer dististyle acicular, blackened, scarcely sinuous on distal half. Blades of gonapophyses narrow, the tips pale, long-attenuate.

Holotype, ♂, Potrerillos, altitude 3,500 feet, May 14, 1934 (Brown).

Orimarga (Orimarga) melampodia is closest to *O. (O.) dampfi* Alexander, of Mexico, differing in the blackened legs, details of venation, as the short R_{2+3} and long R_{1+2} , and in slight details of the male hypopygium.

Helius (Helius) distinervis new species.

General coloration brownish black; legs dark brown, the outer tarsal segments paling to obscure yellow; wings with a weak brown tinge, stigma oval, medium brown; *m-cu* lying far distad, nearly twice its own length beyond the fork of *M*; male hypopygium with numerous small spinulæ surrounding the two major apical spines of the outer dististyle.

MALE.—Length about 4.5 mm.; wing 4.6 mm.

Rostrum not apparent in the unique type. Antennæ small, dark brown, the outer segments broken. Head dark brown.

Thorax uniformly brownish black, without stripes. Halteres dusky throughout. Legs dark brown, the outer tarsal segments paling to obscure yellow. Wings with a weak brown tinge, the prearcular region and cells *C* and *Sc* slightly darker brown; stigma oval, medium brown; veins dark brown. Costal fringe of moderate length. Venation: *Sc* long, *Sc*₁ ending about opposite five-sixths the length of the long *Rs*, *Sc*₂ at its tip; branches of *Rs* rather strongly diverging at outer ends, cell *R*₄ at margin wider than cell *R*₂; inner end of cell 1st *M*₂ strongly narrowed; *m-cu* lying far distad, about opposite *r-m* and nearly twice its own length beyond the fork of *M*.

Abdomen black; hypopygium and sternites a little paler. Male hypopygium with the outer dististyle unequally bifid at apex, with numerous additional spinulae grouped around the apex. Inner dististyle subequal in length, gradually narrowed outwardly. Lateral tergal arms directed mesad as parallel-sided flattened blades, the tips obtusely rounded.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 20, 1935 (MacSwain).

Helius (Helius) distinervis is very different from other described species, especially in the unusual position of the *m-cu* crossvein. The rostrum is invisible in the unique type but the generic reference seems undoubtedly to be correct unless a new group might be deemed necessary to receive the species.

Ischnothrix (Ischnothrix) patens new species.

General coloration of thorax medium brown; antennae (female) elongate, exceeding one-half the body in length; legs pale brown; wings with a strong brownish yellow tinge, the long-oval stigma pale brown; *R*₃ short, nearly erect; cell *M*₂ open by atrophy of basal section of *M*₃; *m-cu* shortly beyond fork of *M*; abdominal segments dimidiate, brown, the caudal half light yellow.

FEMALE.—Length about 5.5 mm.; wing 5 mm.; antenna about 3 mm.

Rostrum pale brown; palpi dark brown. Antennae (female) exceeding one-half the length of body; scape and pedicel pale, flagellum black; flagellar segments long-cylindrical, with relatively short verticils scattered throughout the length. Head pale brown.

Mesonotum medium brown, unmarked, the pleura a little brighter. Halteres yellow, the knobs infuscated. Legs with the coxae testaceous brown; trochanters obscure yellow; remainder of legs pale brown, the terminal segments dark brown. Wings with a strong brownish yellow tinge, the long-oval stigma pale brown; cells *C* and *Sc* brighter yellow than remainder of ground; veins pale brown, *Sc* more yellowish. All veins beyond cord with macrotrichia. Venation: *Sc* relatively long, *Sc*₁ ending beyond midlength of the arcuated *Rs*, *Sc*₂ about mid-distance between origin of *Rs* and tip of *Sc*₁; *R*₂₊₃₊₄ elongate, gently arcuated; *R*₃ short, nearly erect; distance on margin between veins *R*₁₊₂ and *R*₃ a little greater than the

length of latter; R_4 a little shorter than R_{2+3+4} ; cell M_2 open by atrophy of basal section of M_3 ; cell 2nd M_2 about three times its petiole; $m-cu$ shortly beyond fork of M .

Abdominal segments dimidiate, brown, the caudal half of each segment light yellow, the extreme base of the segments more vaguely brightened. cerci slender.

Holotype, ♀, Potrerillos, altitude 3,000 feet, May 5, 1935 (MacSwain).

Ischnothrix (*Ischnothrix*) *patens* is readily distinguished from all previously described Neotropical species by the open cell M_2 of the wings. Except for this character, it much resembles *I. (I.) argentinicola* (Alexander) of Argentina. It is entirely distinct from the two species previously known from northern South America, *I. (I.) brevisector* Alexander, of Venezuela, and *I. (I.) lloydi* (Alexander), of Colombia. The genus *Ischnothrix* Bigot had not been found in America north of Colombia and is not included in Curran's "North American Diptera," 1934.

***Lipsothrix neotropica* new species.**

General coloration pale yellow; legs whitish; wings whitish subhyaline; $m-cu$ at near two-thirds the length of cell 1st M_2 ; male hypopygium with the interbase pale, long and sinuous, gradually narrowed to hairlike points.

MALE.—Length about 6.5 mm.; wing 7 mm.

Rostrum pale yellow; palpi a little darker. Antennæ with scape and pedicel pale yellow, flagellum brown; flagellar segments oval, the verticils exceeding the segments in length. Head pale yellow.

Thorax uniformly pale yellow. Halteres pale yellow, the knobs weakly darkened. Legs whitish, even the last tarsal segment scarcely darkened. Wings whitish subhyaline, unmarked; veins brown. Macrotrichia of veins long and conspicuous. Venation: Sc_1 ending just beyond fork of Rs , Sc_2 a short distance from its tip; Rs in longitudinal alignment with R_{2+3+4} ; R_{2+3} subequal to R_{1+2} ; veins R_3 and R_4 diverging at margin so cell R_2 is only a little more than one-half as extensive at margin as cell R_3 ; $m-cu$ at near two-thirds the length of cell 1st M_2 .

Abdominal tergites pale brownish yellow, sternites whitish; hypopygium pale except for the blackened outer dististyle. Male hypopygium with the interbases pale, long and sinuous, gradually narrowed to hairlike points.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 7, 1935 (MacSwain).

Lipsothrix neotropica is the first Neotropical member of the genus to be discovered. It is very distinct from the only known Nearctic species, *L. sylvia* (Alexander), differing markedly in

the venation, as the distal position of *m-cu*, and in the structure of the male hypopygium, especially of the interbases. The individual, while pale, is certainly not in teneral condition.

Gonomyia (Gonomyia) remota obtusistyla new subspecies.

MALE.—Length about 4.5 mm.; wing 4.5 mm.

Close to typical *remota* Alexander, of southern Mexico and Salvador, differing in details of structure of the male hypopygium. Inner dististyle with the outer arm stouter, less spine-like in appearance; inner arm obtuse at apex, not extended into an acute spine as in the typical form. Aedeagus with apical blade more expanded.

Holotype, ♂, Potrerillos, altitude 3,500 feet, May 12, 1934 (Brown). Paratopotypes, 2 ♂♂, altitude 3,000 feet, May 14–15, 1935 (MacSwain).

Gonomyia (Lipophleps) macswaini new species.

Belongs to the *manca* group; general coloration dark brown, the pleura with a longitudinal whitish stripe; antennæ black throughout; legs brownish black to black; wings with a strong brownish tinge, the stigma a trifle darker but very poorly delimited; *Sc*₁ ending opposite origin of *Rs*; male hypopygium with outer apical angle of basistyle produced into a long fleshy lobe; dististyles subterminal, asymmetrical on the two sides; phallosome with a single blackened rod.

MALE.—Length about 3.5 mm.; wing 4 mm.

Rostrum and palpi black. Antennæ black throughout. Head dark, variegated on posterior portion by yellow.

Pronotum and lateral pretergites light yellow. Mesonotal præscutum and scutal lobes dark brown; median area of scutum testaceous; scutellum yellow, dark at base; mediotergite darkened posteriorly, slightly paler on cephalic portion. Pleura dark brown, with a broad whitish longitudinal stripe extending from behind the fore coxæ to the abdominal sternites; dorsopleural membrane pale. Halteres dark, the knobs broken. Legs with the coxæ brownish testaceous; remainder of legs brownish black to black. Wings with a strong brown tinge, the stigma a trifle darker but very poorly delimited; prearcular region and costal field slightly paler than the ground; veins brown. Venation: *Sc*₁ ending opposite origin of *Rs*, *Sc*₂ removed from its tip; *Rs* relatively long, exceeding one-half its anterior branch; cell 1st *M*₂ closed; *m-cu* at fork of *M*.

Abdominal tergites dark brown, sternites obscure yellow. Male hypopygium with outer apical lobe of basistyle long and slender, subequal in length to the body of style. Dististyles of the two sides asymmetrical, one side terminating in two slender rods, the inner of which is heavily blackened, the outer straight and paler; at base of these rods an additional tiny black spine; style of opposite side with a long base, at apex expanded into an

asymmetrical head that is conspicuously hispinous. Phallosome complex, asymmetrical, with a single blackened rod.

Holotype, ♂, Potrerillos, altitude 3,000 feet, May 5, 1935 (MacSwain).

Gonomyia (*Lipophleps*) *macswaini* is named in honor of the collector of many of the interesting species discussed in this report. The species is readily told from all other members of the *manca* group by the structure of the male hypopygium, especially the prolonged lobes of the basistyles, in conjunction with the strongly asymmetrical dististyles.

SOME SYNONYMY IN NEOTROPICAL HESPERIIDÆ (LEPIDOPTERA)

BY E. L. BELL

Kirby in his "Catalogue of the Collection of Diurnal Lepidoptera Formed by the Late William Chapman Hewitson," p. 243, 1879, lists "*Nisoniades selma* Hewitson" from "Cayenne, Amazon, Venezuela, Rio."

The writer could find no published description of this name by Hewitson and wrote to Brigadier W. H. Evans of the British Museum for information about it and has received a reply stating that it is a manuscript name and that the specimens in the Hewitson collection labelled "*selma*" are *Chiomara mithrax* Moeschler.

Mabille, "Genera Insectorum," xvii, p. 74, 1903, lists "*Chiomara salma* Hewitson," an evident misspelling of "*selma*."

Nisoniades selma Kirby (Hewitson ms.) and *Chiomara salma* Mabille are thus disposed of as synonyms of *Chiomara mithrax* Moeschler.

CHARACTERISTICS OF CERTAIN WESTERN CICADAS

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Many differences exist in cicadas other than the morphological characters used in the taxonomic differentiation of genera and species. The habits, broods, locations, songs, seasons, plant associations, time and activities may be so constant that they may be typical of certain groups and may even be of value in the determination of closely allied species. With a knowledge of these factors, one may be reasonably certain of what species or group of species may be expected to be found under certain conditions.

The season for most of the far western cicadas is chiefly the early summer and by the latter part of the season, most of their visible activities are over with. *Okanagana* and the allied genera are dominant and *Tibicen* is represented by only a few species which are not typical of the genus in the east. By the latter part of July, the broods have scattered and only rarely can a song be heard. A record for *Okanagana bella* Davis is therefore unusual both for time and altitude. It was observed on September 19, 1932 in Utah County, Utah, east of Mt. Timpanoogas (altitude 11,957 ft.) in the valley known as Little Provo Hole at an altitude of approximately 9,000 feet.

All the determinations of the species considered here have been made by Mr. Wm. T. Davis of Staten Island, New York and he has reviewed the manuscript. Dr. Walter Cottam of the University of Utah determined the plants and John W. Sugden, III assisted in the collection. The author's thanks is expressed.

Cacama crepitans Van Duzee

This cicada was found (June 24, 1938) on the hills of the Coast Range, Orange County, California, east of San Juan Capistrano. They were on the steep hill densely studded with *Opuntia* cactus, but no insects were found on the cacti notwithstanding the

popular name "cactus dodger," but were always located on the other plants of the region and often were on dead twigs.

The song of the *Cacama*, markedly different from that of *Okanagana*, was given in sequences of ten to twelve seconds. During the first five or six seconds, the song was rapid and shrill and then it decreased through the remaining interval to be again repeated without break in the continuity. The change from the low, dull song to the high, shrill interval was rapid and that from the opposites was considerably longer, taking about one second of time. During the first part, the full song, the abdomen was elevated and the opercula widely opened. During the remaining period, the abdomen was depressed and the opercula were then closed. The depression of the abdomen and the closure of the opercula damped the sound and with the alternate opening and closing, the song had an undulating character. The same insect observed at Point Loma, California, several years ago (June 12, 1931) had the same undulating character but the variations were slight. Only in cicadas with opercula covering the tympanal cavities is such a song possible.

When captured there was a high-pitched, shrill, continuous song. Flying was during the low part of the song, not during the height with the abdomen raised.

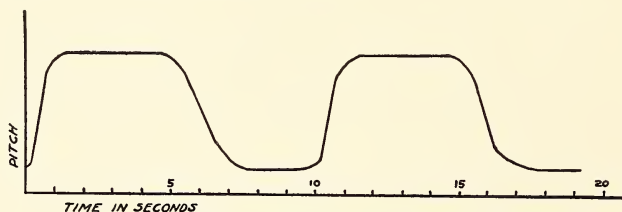


FIG. 1. Song of *Cacama crepitans* Van Duzee.

Clidophelps pallida Van Duzee

Clidophelps pallida was found in the valleys of Southern California (near Elsinore, Calif. June 24, 1938) on *Eriogonum*. There was a definite plant association and the insects were found wherever the plant occurred. When the insects flew they invariably lighted on the plant and not on other bushes or plants in the vicinity.

The characteristic song was a loud rasping rattle, very similar

in quality to the rattle of the rattlesnake. Many other cicada songs have been described as resembling this sound. Putnam (1881) writes that the note of *O. rimosa* is a "rattling noise, exceedingly like that of a rattlesnake. This resemblance was so close that one day in 1873, in the Shoshone Mountains, I was attracted by a noise which I took to be one of those insects, and stopped to pick it up, when I suddenly discovered a large rattlesnake in its stead" (quotation, Myers, 1929 p. 221 and Davis 1921 p. 50). Englehart states that the song of *O. schæfferi* "closely resembles the whirring noise produced by a rattlesnake and that on one occasion in June, 1917, in Washington County, Utah, he came very near being bitten by a snake while searching in a small bush for the supposed cicada" (quotation, Davis, 1921, p. 50). My notes concerning the same *Clidophelps*, observed in San Diego County, California (June 12, 1931) were much the same. The similarity to the rattlesnake rattle was definite. With the song of any of the Okanaganas, I have never had the impression of hearing a rattlesnake, however, the difference in the sounds may be more marked because of familiarity with the reptile.

During the time of the rasping rattle, the wings were flattened and slightly opened. This occupied about ten seconds of time and none that were timed continued longer than twelve seconds. Many of the insects in a location would give the rattle sound in unison. When it was started, several could be heard to start within a fraction of a second and all would stop at almost the same instant.

In addition, there was a clicking sound, during which the abdomen was jerked up and down. This sound was repeated at a rate as frequent as 140 a minute and could be counted with a watch, much the same as taking a fetal heart tone. When disturbed by being too close, the clicking was less frequent or discontinued. The insects depended upon concealing coloration and sometimes they could be picked from the stem without attempting to fly.

Okanagodes gracilis Davis

From a few miles north of Boulder City, Nevada (June 25, 1938) until off the plateau, the insects were found or heard

wherever a plant association occurred. Three plants predominated and were always together. The cicadas were found only on the first two.

1. The Bottle-plant, *Eriogonum inflatum*, a pale green, spindly plant with swollen hollow stems.

2. Burro-weed, *Franseria dumosa*, a small, grey, sage-like plant, growing from six to eight inches in height.

3. Creosote-bush, *Covillea tridentata*, an evergreen shrub with deep green leaves, growing about two feet in height and giving the only color to the region. It is the characteristic plant of the area, the Covillea belt.

At the time, the temperature was estimated to be 110° F., which was apparently too conservative as at Boulder City, the official reading in the shade was 114° F., and at Las Vegas, it was considered "very warm." Of course in the desert there was no shade. Time 11 A. M.

The song, a series of short "zips," was repeated, when not disturbed, at intervals of 160 a minute. When approached, the song was usually stopped or reduced in frequency and when it was resumed, a few chirps were given rather cautiously before starting the full song. Invariably the song seemed to be coming from a plant nearer than the one occupied by the insect. Even when allowance for error was considered, the site often was beyond the estimated location. When disturbed and flying, the male would give a short, rapid, continuous song or as often would fly without making any noise. The song seemed to resemble a mechanism that was wound up and released at frequent intervals for a split second, *e.g.*, a movie camera with the lever repeatedly pressed. Protective oblitative coloration was especially marked; a pale insect on pale plants on a hot desert.

The songs of many of the Okanagana are very similar and have few distinguishing characteristics. As a rule, the song is given only during the hottest part of the day, never at evening and rarely unless the insects are in the bright sunlight, even being stopped when the shadow of a cloud comes over. Captive specimens of *Okanagana bella* and *Okanagana striatipes* have been induced to sing when a vacuum cleaner was started.

Okanagana rubrovenosa Davis

At Gold Run, California, (elevation 3224 Ft., June 13, 1938)

Okanagana rubrovenosa were on the manzanita bushes, which in this locality grew from three to six feet in height. The cicadas were usually on the smaller branches and were often out toward the ends carrying the leaves.

The song, a shrill whistle, was stopped when the insect was approached and resumed if the observer remained quiet. During the song, the abdomen was elevated which had the effect of opening wider the tympanal cavities. Sometimes it would be continued while the insect was flying. In addition, a clicking sound was made by flicking the wings. The females probably can make the same sound, but those that were observed were quiet and did not even try to fly when collected. The same insects collected on manzanita in Washington County, Utah (July 6, 1930 and June 11, 1932) acted much the same, but did not click their wings.

Okanagana bella Davis

Okanagana bella as frequently observed in the canyons about the valleys of the Great Salt Lake and at Fish Lake, Sevier County, Utah (July 2, 1930) and Mt. Hood, Oregon (July 23, 1935) had the same even, high-pitched song of *Okanagana rubrovenosa*. If the two could be heard together, a difference might be detected. *Okanagana bella* is found on willows (*Salix* sp.) birch, quaking aspen (*Populus tremuloides*) and other trees in the canyons and often at higher elevations than other cicadas. The wing clicking, however, has not been observed with this species.

Okanagana vanduzeei Distant

Okanagana vanduzeei were found at several localities. At Mill Valley and Muir Woods, California (June 17, 1938) they were on the grass covered hills. The song was more even, but about the same pitch as that of *Okanagana striatipes* and their actions were very similar. They were active, flew readily and were difficult to approach. After flying, the insects would often circle back and alight, head upward, at a not very great distance from the starting point. At Union, Oregon (July 21, 1935) on a sage brush covered hill, the flight was often at a level above the sage, when suddenly they would drop to a lower level and continue until they crashed into another bush. At Soquel and Elsinore, California (1938) the insects were also on grass.

Okanagana californica Distant

Okanagana californica at Elsinore, California (June 24, 1938) was on grass and had a song and actions indistinguishable from those of *Okanagana vanduzeei*.

Okanagana luteobasalis Davis

Okanagana luteobasalis is only associated with the sage brush and is found over these areas on the plateaus of southern Utah. The type brood of this species was observed near the town of Hatch, Garfield County, Utah (June 5, 1931) on the Paunsaugunt Plateau. (Davis, 1935 p. 302. The type locality is in Garfield County, not Davis County.)

The brood had emerged just south of the town and to the east of U. S. Highway 89. In the area, which was about 100 feet in diameter, the sage was scrubby and only a foot or less in height and was quite definitely demarcated from the surrounding country. In this limited area were found thousands of exuvia, although the adults were beginning to spread out, the skins exactly marked the limits of the brood. Five to twenty could be found around every sage brush. It seemed probable that the large number of nymphs, feeding on the roots, had caused the plants to suffer over the limited area. With this in mind, the site was examined from an elevation west of the road and the area of scrubby sage and exuvia was essentially the same.

Most of the insects were easily captured as is usually the case with recently emerged broods. Some were copulating and others had just emerged and were still green, with limp, ghostly, pale green wings. The pronotum on either side of the mid line was the first to become dark. The ocelli stood out as orange spots and the compound eyes were brown. Some of the females were ovipositing on the sage, but most of them had chosen the rabbit brush. They would usually take about three minutes to the nest. One continued to work for ten minutes, but this may have been the last nest, as it was not filled with eggs and there were several other completed nests in a line on the stem above. All the ovipositing females were head down on the stems.

Just north of Nephi, Utah (June 26, 1938) in a sage brush field, a cicada was heard and when collected, was found to be

Okanagana luteobasalis. It was on the stem of the central part of the sage. No other of this species was found, although they were searched for. Other broods of the same species have always been in large numbers so this specimen may have been from a more distant location. In the same general region, *Okanagana utahensis* was also collected, but these insects were always on the leafy parts of the plant.

Okanagana utahensis Davis and *Okanagana striatipes* (Haldeman)

Most of the *Okanagana* songs are very similar and tend to be even and continuous. When they are singing in the same locality, slight differences in the quality become more evident. Both *Okanagana utahensis* and *Okanagana striatipes* are found on the sage brush and grass-covered foothill of the Wasatch Mountains, on the terraces of old Lake Bonneville, east of Salt Lake City. The songs have enough contrast to distinguish the insects by the sound alone.

At Fort Douglas, Utah (July 4, 1938) *Okanagana striatipes* were fairly numerous, alert and well scattered. A few exuvia were found on the ground or clinging to the plants. A female flew to a singing male, alighted on the stem, approached the male and then assumed a parallel position. The male's song was reduced to a few feeble clicks and copulation began. The act was timed and found to continue for 10 minutes, during which they were quiet and could be handled without attempting to escape.

In *Okanagana striatipes*, the song is loud for the size of the insect and it has a definite rapid undulating character giving a quivering effect. That of *Okanagana utahensis* is finer, more even and somewhat weaker even though the insect is larger.

Okanagana utahensis was the common cicada along the Wasatch Drive, southeast of Salt Lake City (July 3, 1938) on the sage brush flats. Most of the insects were located on the leafy parts of the plants. Only an occasional *Okanagana striatipes* was found. A female, *Okanagana utahensis*, was first observed as it crawled along side of a male whose song had been heard. Copulation immediately took place and the song was instantly discontinued. The act was timed and took 14 minutes during which time the insects clung to the sage in parallel positions.

Okanagana synodica (Say)

A large brood of *Okanagana synodica* was observed in Emery County, Utah (June 7, 1928). At first, the sound was mistaken for the humming of the carburetor of the car. In the field, so many were buzzing that it was impossible to locate the position of any individual. After examining the low, sage-like bushes, thousands of the insects were found. Fifteen or twenty could be easily collected on a bush not over a foot high. The note, similar to the typical *Okanagana* song, was not very loud, but shrill and long continued and what the individual lacked in volume was made up for by the large numbers. Very few would fly if disturbed, but would remain on the bushes and could be collected by hand. Others would become quiet when disturbed and fall to the ground, where their color closely resembled the buff colored soil. Many were mating. The exuvia were on the ground or attached to the stems.

Okanagana fumipennis Davis

Okanagana fumipennis as observed in San Juan County, Utah (June 8, 1928 and by H. W. Pickett, June 22, 1932) were on the wide sage brush flats of the region. They were easily captured, were poor flyers and if thrown in the air, they would fall to earth a few feet away. None voluntarily took to wing. The song was strong and long continued. Many exuvia were on the ground and clinging to the sage. This species was originally confused with *Okanagana schæfferi*, (Davis, 1932, 251).

Okanagana schæfferi Davis

The habits and songs of *Okanagana schæfferi* were entirely different from *Okanagana fumipennis* when the former was observed along the Mt. Carmel-Zion Park Highway in Utah (June 5, 1931). The insects were found only on the junipers (*Juniperis utahensis*) which were very common in the region. They were active and flew readily. A few were copulating. The song had a distinct metallic quality and when several were singing, the sound resembled the noise made by the safety razor blade sharpeners in the boot-black stands a few years ago. It was long-continued and louder than that of the smaller *Okanaganas*.

Platypedia mohavensis Davis

Platypedia mohavensis were in the same juniper trees with *Okanagana schæfferi*. Both sexes made a clicking sound by flicking the wings and because of the large number, the sound resembled a shower of hail or shot dropped on wrapping paper. These insects were not singing.

Platypedia putnami lutea Davis and *Neoplatypedia constricta* Davis

Both *Platypedia putnami lutea* and *Neoplatypedia constricta* were collected in South Willow Creek Canyon, Tooele County, Utah. In May (May 24, 1931) only the former had emerged and the next month (June 14, 1931) both were present. The songs were similar, not loud and both sexes of both species were making the wing-clicking sounds. They were found on rabbit brush (*Chrysothamnus* sp.) and sage (*Artemisia tridentata*). *Platypedia putnami lutea* have been collected on juniper in the Kaibab Forest (June 11, 1924) and on willow (*Salix* sp.) in the canyons of Salt Lake County, Utah (May 30, 1930).

Tibicinoides mercedita (Davis) and *Tibicinoides cupreo-sparsus* (Uhler)

Tibicinoides mercedita at Dixon, California (June 13, 1938) had a song very similar to that of *Okanagana vanduzeei* and other allied species. The smaller *Tibicinoides cupreo-sparsus* in San Diego County, California (June 12, 1931) had an even song, which was not very loud and was usually stopped before the insect could be located. The dark color gave a remarkable concealing coloration when the insect was clinging to the dark, dry twigs and branches of a small shrub.

Eighteen western species of seven genera of cicadas have been considered. Ten species were observed and collected during 1938 and to these notes have been added other observations made in recent years.

NEW FLEAS

West Coast Crested Fleas Corypsylla and Nearctopsylla (Pacific Univ. Bull. Vol. 37, No. 1, Mar., 1940, 10 p., 1 pl.). *American Mole and Shrew Fleas* (Pacific Univ. Bull. Vol. 37, No. 2, April, 1940, 9 p., 2 pl.). *West Coast Catallagias* (Pacific Univ. Bull. Vol. 37, No. 3, May, 1940, 4 p., 1 pl.) by C. Anderson Hubbard.

In these three papers, Doctor Hubbard describes one new genus and nine new species of fleas, examples of which have been deposited in colleges, universities and museums in the eastern, southern, western and central areas of the United States, as well as in Canada and abroad, thus making the future study of them easier for students and specialists. Doctor Hubbard questions the taxonomic value of the "incrassation" in *Corypsylla* and in his paper on American mole and shrew fleas, presents information designed to improve the host records, for certain species, as given by Irving Fox in "Fleas of Eastern United States," noted in this Journal in volume 48, No. 1, p. 32. Other information is presented, adding to the taxonomic and biologic knowledge of our American Siphonaptera.—H. B. W.

THE SARCOPHAGINÆ AND THEIR RELATIVES IN NEW YORK, PART I¹

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INTRODUCTION

An attempt is made in this paper to define the limits of a small group of muscoid flies, the *Sarcophaginæ* and their relatives in so far as the species, which occur in New York, are concerned. A study of the structures of the male hypopygium of the *Sarcophaga* has been included in the hope that a better understanding of the relationship of the species to each other might be obtained.

The correct understanding of North American *Sarcophaginæ* must be based upon the work of Dr. J. M. Aldrich. Twenty-two years ago Aldrich (1916) published his "*Sarcophaga* and Allies" which produced an orderly arrangement of the group for the first time. Several years later he had an opportunity to visit the European Museums and study the types of the early authors. As a result of this study Aldrich (1924, 1930) pointed out the synonymy of many names that were in common use in American literature.

Reference must also be made to the important studies by Dr. R. R. Parker which were published in many widely scattered papers from 1914 to 1923. Parker described several new species and made a careful study of the structures of some species of the *Ravinia* and *Boettcheria* groups of the genus *Sarcophaga*. We must also depend upon Parker (1916, 1919) for our understanding of *Sarcophagrtia*.

A discussion of North American *Sarcophaginæ* would not be

¹ As this study was completed while the writer was at Cornell University this article is a contribution from the Department of Entomology, Cornell University, Ithaca, New York. The writer desires to acknowledge assistance from Prof. Robert Matheson, Prof. O. A. Johannsen, Cornell University; Mr. David G. Hall, U. S. National Museum; Dr. Richard Dow, Boston Soc. Nat. History; and Mr. H. G. Reinhard, Texas Agricultural Experiment Station. The writer is also grateful for the valuable assistance of his wife, Mabel M. Hallock, during the proof reading.

complete without reference to Mr. David G. Hall who has published (1926-1937) about a dozen papers dealing with American *Sarcophagidæ*. The most important of his papers are "*Sarcophaga pallinervis* and related species in the Americas" (1928) and "*The Sarcophaginæ of Panama*" (1933).

There are also many taxonomic papers by Dr. C. H. T. Townsend which must be considered for a complete understanding of the New York species. The remaining taxonomic, biological and economic papers, which have been consulted, are widely scattered in the literature. As a result it seems wise to give a summary of this information dealing with New York *Sarcophaginæ* and their relatives.

The tribe, *Miltogrammini*, of the *Sarcophagidæ* will not be considered in this paper as these flies have been very well treated by Allen (1926). Very little new information about the New York *Miltogrammini* has been obtained during the past twelve years. The remaining species of *Sarcophagidæ*, which are known to occur in New York and a few others which are likely to be found in New York, are discussed in this paper. Keys are given to separate the genera of this portion of the family and the species occurring in the different genera. The discussion of the species will deal largely with a few distinctive characters, their distribution in New York and the known hosts or other larval food habits of the *Sarcophaginæ*. The male genitalia will be considered in so far as they tend to aid in the illustration of the group relationships and help in the determination of the species.

The known distribution for each species and the total seasonal occurrence of the adults is given for New York. Credit for the collection of the different species is not repeated, as this information has been given by Leonard (1928) and Hallock (1937).

The writer has found that special methods of preparing the male genitalia for study are necessary. A combination of several of the published methods with some variation has proved most satisfactory. When there is an abundance of material the genitalia of a few specimens of each species are dissected, soaked in potassium hydroxide to remove the soft muscle parts, etc., washed in several changes of water to remove the potash, transferred to cello-solve and then mounted on slides in Canada balsam in such a

manner as not to flatten out the parts. The minute details of the specimen, which cannot be seen plainly with a binocular, may now be examined to advantage with the higher powers of the compound microscope. This method has been used by Patton (1933) and Senior-White (1924) but Hardy (1927) objected to the use of potash. Other specimens should be studied with the genitalia *in situ* as described by Parker (1914) and Aldrich (1916) to correct any errors. The potash may dissolve some of the more delicate parts of the ædeagus or as a result of the dissection and soaking in potash a portion of a sclerite may drop off and be lost. This is very likely to occur in the case of the portion of the sclerite immediately surrounding the lower portion of the V of the fifth sternite.

LIFE HISTORY

The *Sarcophaginæ*, as all other Diptera, are insects with complete metamorphoses. They pass through four stages, egg, larva, pupa and adult during their life cycle.

EGG: Most *Sarcophaga* do not lay eggs but larviposit first instar larvæ, upon the host or larval food. In this case the entire embryological development has taken place within the female fly and the larvæ have hatched before larviposition.

In cases where there is an abundance of meat or other proper food for the larvæ the female fly may oviposit eggs upon the meat. This oviposition was observed by Smith (1933) during his study of *Sarcophaga securifera*. He observed that these eggs either hatched immediately or within the following eight or nine hours.

The writer has dissected female flies of *Sarcophaga bullata*, *S. latisterna*, and *S. misera* var. *sarracenioides* and found larvæ which had already hatched. Several other species of *Sarcophaga* have been observed to larviposit when upon the point of death in a killing jar.

LARVA: Each larva passes through three instars during the development. The first instar is normally very short. Smith (1933) pointed out that the first instar was completed in thirteen to sixteen hours at a temperature of 80° F. He also found that the second molt occurred ten to twenty hours later. The larvæ became completely developed in about six days after deposition and migrated to the soil to pupate.

Under normal temperature conditions Hallock (1929) found that the larvæ of *S. latisterna* developed in four to five days. At the same time the larger species, *S. bullata*, took an average of eleven days to develop. It was also observed that *bullata* developed slower during cool periods in the summer but its development was completed in six to ten days during the hot periods of the summer. This should be contrasted with the slow development of the larvæ of *S. fletcheri* in pitcher plants. Larvæ which had already reached the third instar stage during July, 1936, were observed to feed for a period varying from six to ten days before pupation. This would indicate the possibility that the entire larval stage may last about a month.

PUPA: The sarcophagid pupal period is subject to considerable variation at different seasons of the year. The writer found in early September, 1935, that *S. bullata* pupated but the flies did not emerge when kept at the normal fall temperatures. During the summer months the pupal period lasted normally ten to fourteen days. Smith (1933) found that *S. securifera* remained in the pupal stage from ten to thirteen days when kept at a temperature of 80° F.

ADULT: There is very little information available about the length of life of the adult fly. Smith (1933) reported that the maximum length of life of *S. securifera* was about a month. He also found that oviposition did not take place until eight to fourteen days after emergence. It also appears that meat must be included in the diet of the adult fly in order that larvæ will develop. The writer's experience in rearing *S. bullata*, *S. sarcenoides* and *S. securifera* agree with Smith's findings that meat is a necessary part of the fly diet in order that larvæ may develop.

The number of generations in any season depends upon the species, availability of suitable larval food, and temperature. *Sarcophaga cimbicis* has been found flying in New York from May until October. It attacks a wide variety of hosts so it should be able to find larval food easily. The larval development is rapid and a cool period, during the summer, does not appear to delay development as much as in the case of some of the species, such as *bullata*, for example. There must be several overlapping genera-

tions although the complete life history of the parasite, *cimbicis*, has not been worked out. This long period of adult abundance may be contrasted with *Sarcophaga aldrichi* which occurs in New York from late May until early July. This species appears to be limited to a few Lepidopterous hosts and *Malacosoma disstria* is the preferred one. Although the life history has not been completely studied, available data points to one generation with a fairly long period of adult emergence. The scavenger groups, including the dung and dead animal feeders, have several overlapping generations.

THE MALE HYPOPYGIAL STRUCTURES

The terminology which has been followed in this study is adapted from Snodgrass (1935). A few terms which seem more descriptive of the structure have been adapted from Patton (1933-1935) after studying his series of papers in the "Annals of Tropical Medicine and Parasitology." A comparison of the terms which have been used by workers on the Sarcophagidæ, is given in Table 1.

A careful study was made of the hypopygium of about 30 species from New York and the internal hypopygial structures are illustrated in this paper (Figs. 1-97). The structure of *Hypopelta scrofa* is described and compared with the variation found in the other species of *Sarcophaginæ*.

The visceral part of the abdomen of *H. scrofa* consists of segments one to five, but the first segment has been obscured by reduction and union with the second. As a result the segments (one to four) mentioned in all systematic papers are segments two to five of the Dipterous abdomen. In order to avoid confusion the systematic system has been adapted in the systematic part of this paper when referring to the first four segments of the abdomen. The references to the hypopygial structure will be made by a name assigned to the part or, when mention is made by segment number; the true abdominal segment number will be used in the case of all hypopygial segments. Segments six to ten and the fifth sternum are included in the hypopygial structures and many of these structures have valuable taxonomic characters.

There has been considerable reduction, obliteration, and modification of the male genitalia structures in *H. scrofa* and the other

Sarcophaginae so it is difficult to correctly name the structures. The fifth sternum (Fig. 2) is a convex sclerite with a deep U cut in its caudal margin. *Hypopelta scrofa* has two raised projections on the base of the U, which are lacking in the majority of the *Sarcophaginae*. The U of *H. scrofa* becomes a V in the *Sarcophaga* as illustrated by *S. bullata*. Segment six appears to be obliterated as in the case of *Pollenia rudis* studied by Snodgrass (1935) and segment seven consists of a smaller tergal plate than in the case of *rudis*. The seventh spiracle is present in the membranous walls on the lateral side of the body just cephalad of the eighth segment. The eighth segment has a well developed tergum which has often been mentioned in American taxonomic literature as the first segment of the hypopygium. The sternum of the eighth segment, which helps to support the fifth sternum, is reduced to a narrow sclerotic band, which is incomplete on the right side. The eighth sternum has no taxonomic value and is not illustrated. The tergum of the ninth segment has been called the second segment of the hypopygium in taxonomic literature. The sternum of the ninth segment projects forward and upward from the lower angles of the ninth tergum and forms the dorsal wall of a large pouch which is invaginated within the eighth sternum. The phallic organs normally extend into this pouch. The ninth sternum (Fig. 4) is a broad plate with its posterior angles produced as two arms which embrace the base of the ædeagus. The plate in the case of *H. scrofa* has been reduced and the arms enlarged but *Sarcophaga hæmorrhoidalis* has a normal ninth sternum (Fig. 62). There are two lateral bars which connect the ninth sternum to the tenth segment. The tenth segment has been reduced to a membranous area surrounding the anus. There are two lobes connected with this tenth segment which Snodgrass has termed lateral lobes but in this paper they are called anal forceps (Figs. 1, 3). The term, forceps, has been used by Aldrich and Parker and is very descriptive of the sclerite. The lobes which are attached to the ninth segment and given no definite name by Snodgrass, are called accessory plates (Fig. 1) which is the name used by Parker (1914) and Aldrich (1916).

The phallic organs of *Sarcophaginae* consist principally of a well developed ædeagus and supporting basal structures. The struc-

ture which has been termed ædeagus by Snodgrass has been called phallosome by Patton, and penis by Aldrich, Parker and several other taxonomic writers. The ædeagus is a large irregular structure (Fig. 1). The sclerites called anterior and posterior claspers (Fig. 1) by taxonomic writers are the lateral processes of the ædeagus. The shape of the claspers has considerable value as a taxonomic character but is less important than the ædeagus. There is a very small sclerite at the base of the claspers which Parker (1914) termed the fulcral plate. This plate, which varies very little in the species studied, has no importance in classification and is not illustrated. The basal apodeme (Fig. 5) is represented by a low thecal fold. The free end of the basal apodeme extends cephalad and the attached end surrounds the base of the ædeagus. The basal apodeme of *H. scrofa* is broader and shorter than the average *Sarcophaginæ* which is illustrated by *Sarcophaga bullata* (Fig. 54), a typical *Sarcophaga* species. The basal apodeme serves for muscle attachment. The sperm pump sclerite (Fig. 6) is situated above the basal apodeme and serves for muscle attachment. The sperm pump sclerite is connected with the ejaculatory bulb, which connects with the ejaculatory duct. Distal to the ejaculatory bulb the duct enters the base of the phallus and thus connects with the ædeagus.

Most of the structures discussed above have been illustrated for the species of *Sarcophaga* which occur commonly in New York. These structures will be discussed further under the genus to show the relationship of the groups.

CLASSIFICATION

The limits of a small group of New York Muscoid flies, the *Sarcophaginæ* and their relatives, will be outlined in the following pages. These flies belong to the order *Diptera* and the family *Sarcophagidæ*.

All the flies in this group have a longitudinal seam along the upper outer edge of the second antennal segment. The arista is generally plumose half its length but in some cases it may be only pubescent or even entirely bare. The mouth parts are well developed and functional. There is a row of strong bristles on the hypopleura. The postscutellum is not distinct and the metanotum

TABLE 1
COMPARISON OF HYPOPYGIAL TERMINOLOGY USED BY WRITERS ON *Sarcophaginae*

Author	Snodgrass	Patton	Aldrich	Parker
fifth sternum	fifth sternum	fifth sternum	fifth sternum	fifth ventral plate
seventh tergum	seventh tergum	sixth tergum	first segment of hypopygium	first genital segment
eighth tergum	eighth tergum	seventh tergum		
eighth sternum	eighth sternum	tenth tergum	second segment of hypopygium	second genital segment
ninth tergum	ninth tergum		forceps	genital sternum
ninth sternum	ninth sternum	ninth tergosternum	accessory plate	accessory plate
anal forceps	lateral lobes	anal cerci	penis	penis
accessory plate	lobes	ninth coxites	anterior clasper	anterior clasper
ædeagus	ædeagus	phallosome		
anterior clasper		anterior part of paramere	posterior clasper	posterior clasper
posterior clasper		posterior part of paramere		fuleral plate
fuleral plate				
basal apodeme	basal apodeme	apodeme of phallosome base		
pump sclerite	central apodeme	sperm pump sclerite		

has only a single convexity. There are three or four notopleural bristles present. The species found in this group are generally grayish with a more or less tessellated abdomen and three to five longitudinal stripes on the thorax.

The *Calliphoridae* are considered as a distinct family at the present time. When the world fauna has been completely studied it may be found necessary to unite the *Sarcophagidae* with the *Calliphoridae*. As there are always border line forms which can be placed only with difficulty the *Sarcophagidae* will be considered here as a separate family.

In this study the tribe *Miltogrammini*, of the *Sarcophagidae* will not be discussed. This tribe includes species with the accessory plate as long or longer than the anal forceps. The impression of the bucca, near the vibrissal angle, is small and not deeply submerged beneath the parafacials and remainder of the bucca. The sternopleuron never has more than two bristles and the segments of the abdomen lacks discal bristles.

The group studied in this paper is divided into twelve genera. In order to make identification as simple as possible all the species in the several genera are included in the same key (which will be given in Part II), although keys to the species are given for the individual genera in some cases.

KEY TO GENERA

- | | |
|--|----------------------------------|
| 1. Arista long plumose | 2 |
| Arista short plumose | 5 |
| Arista bare or only short pubescent | 7 |
| 2. First, third and fifth veins with a row of bristles..... | <i>Johnsonia</i> Coquillett |
| The fifth vein always bare | 3 |
| 3. Fourth vein ending at the tip of the wing | <i>Opsodexia</i> Townsend |
| Fourth vein ending far before the tip of the wing | 4 |
| 4. Front strongly produced, antennal axis strikingly greater than the
vibrissal and frontal profile sloped; the caudal end of male abdomen
appearing truncate | <i>Metoposarcophaga</i> Townsend |
| Front normal; abdomen not truncate in appearance..... | <i>Sarcophaga</i> Meigen |
| 5. Fourth vein ending at the tip of the wing | <i>Opelousia</i> Townsend |
| Fourth vein ending far before the tip of wing | 6 |
| 6. Some pale hairs on back of head; epaulets black..... | <i>Hypopelta</i> Aldrich |
| Only black hairs on back of head; epaulets light colored. | |
| | <i>Sarcophahrtia</i> Parker |
| 7. Median marginal bristles present on first abdominal segment; frontal
bristles not descending below base of antennæ; ovipositor of female
drawn out like an awl..... | <i>Macronichia</i> Rondani |

- Median marginal bristles absent on first abdominal segment; frontal bristles extend below base of antennæ..... 8
8. Abdomen with three rows of shining spots on the second, third, and fourth segments; these are sometimes confluent; fifth sternite entire *Wohlfahrtia* B. & B.
Abdomen pollinose, at most the hind part of segments shining black in certain lights 9
9. Parafacials without bristles; antennæ yellow..... *Erythrandra* B. & B.
Parafacials with a row of bristles; antennæ black..... 10
10. Second abdominal segment with median marginal bristles; anterior acrostichals present; scutellum with a pair of apical bristles.
Oppiopsis Townsend
- Second abdominal segment without median marginal bristles; anterior acrostichals lacking; apical bristles lacking on scutellum.
Laccoprosopa Townsend

DISCUSSION OF GENERA AND SPECIES

Macronichia Rondani

1859. Rondani, Dipt. Ital. Prod., vol. 3, p. 229.

1931. Townsend, Ann. and Mag. of Nat. Hist., vol. 8, p. 379.

Townsend (1931) pointed out that the *Amobia* of authors is *Macronichia* Rondani. As a result our New York species, *aurata* and *confundens*, fall in the genus, *Macronichia*.

Genotype.—*Macronichia unguilans* (Pand.).

Macronichia aurata Coq.

1902. Coquillett, Proc. U. S. N. M., vol. 25, p. 119.

The two species of *Macronichia* found in New York are easily separated as *aurata* has the fourth abdominal segment and remainder of abdomen posterior to it golden yellow pruinose. The fourth abdominal segment is crossed longitudinally by brownish spots.

Length.—7 to 8 mm.

Records.—Owego; Ithaca; Tuxedo. Last of June through August.

Type.—Cat. No. 6233, U. S. N. M.

Macronichia confundens Town.

1915. Townsend (*Amobiopsis confundens*), Proc. Biol. Soc. Wash., vol. 28, p. 20.

The gray pollinose thorax of this species is marked by three to

five black vittæ. The abdomen is gray pollinose, marked with three rows of black spots on the dorsum of the four abdominal segments.

Length.—7 to 9 mm.

Records.—Tuxedo. July 24–28.

Type.—Cat. No. 19134, U. S. N. M.

Opelousia Townsend

1919. Townsend, Proc. U. S. N. M., vol. 56, p. 547.

There is very little known about the habits of the *Opelousia*. Townsend (1935) recorded that *Opelousia* have been reared from snails.

Genotype.—*Opelousia obscura* Townsend.

Opelousia obscura Townsend

1919. Townsend, Proc. U. S. N. M., vol. 56, p. 547.

This species was originally described from three males taken in Louisiana and one male from North Dakota. The species is moderately common in the south. The writer has seen four specimens taken near Atlantic City, New Jersey. As the species has a fairly wide range of distribution it may be expected to occur in New York.

Length.—4 to 4.5 mm.

This fly was recorded by Reinhard (1929) as a parasite of the snail, *Succinea luteola*. The parasite passed the winter in the pupal stage within the shell of its host.

Type.—Male, No. 22249, U. S. N. M.

Opsodexia Townsend

1915. Townsend, Proc. Biol. Soc. Wash., vol. 28, p. 20.

The host relations of this group are unknown. Townsend (1935) described the female reproductive organs for *Opsodexia* and pointed out that the fecundity was very small, "at most a dozen at a deposition." The adult flies have been recorded on *Solidago*, *Baccharis* and other *Compositæ*.

Genotype.—*Opsodexia bicolor* (Coq.).

Opsodexia bicolor Coquillett

1899. Coquillett, Jour. N. Y. Ent. Soc., vol. 7, p. 221.

1915. Townsend, Proc. Biol. Soc. Wash., vol. 28, p. 20.

1935. Townsend, Manual of Myiology, Pt. 2, p. 256.

The legs are largely yellow and in the light form the abdomen is yellow except a dark line along the apex of each segment. The dark form has the femora largely black and the abdomen mostly dark with gray pollinose.

Length.—5 to 6 mm.

Records.—Ithaca; Hancock; Millwood; Corinth; Lake George; Kaaterskill; *L.I.*: Cold Spring Harbor; Wading River; Babylon. June to September.

Type.—Cat. No. 4121, U. S. N. M.

Opsodexia abdominalis Reinhard

1929. Reinhard, Proc. U. S. N. M., vol. 76, art. 20.

The type locality of *Opsodexia abdominalis* is Fabyans, N. H., so the species can be expected to occur in northern New York. The fly was taken on flowers of *Solidago*.

This species may be readily separated from *O. bicolor* by the black densely gray pollinose abdomen. It differs further in that the fourth vein is broadly bowed and lacks a definite angle, and the arista has shorter hairs and is practically bare beneath.

Length.—7 mm.

Type.—Male. Cat. No. 41986, U. S. N. M.

Laccoprosopa Townsend

1891. Townsend, Trans. Am. Ent. Soc., vol. 18, p. 366.

1935. Townsend, Man Myiol., Part II, p. 180.

Curran (1934) placed the species found in this genus in the *Brachycoma* although in the New York State List, 1928, he used the name *Laccoprosopa avium* Curran for a manuscript species. It seems best at this time to retain the genus *Laccoprosopa*.

Genotype.—*Laccoprosopa sarcophagina* Townsend

Laccoprosopa sarcophagina Townsend

1891. Townsend, Trans. Am. Ent. Soc., vol. 18, p. 366.

The genus *Laccoprosopa* is represented by a single species in New York. Leonard (1928) recorded this species in New York as *L. avium* Curr. (manuscript name). Mr. David G. Hall, U. S.

National Museum, has kindly studied the specimens and determined them to be *Laccoprosopa sarcophagina* Townsend. The specimens also were compared with a homotype (determined by Dr. J. M. Aldrich) in the U. S. National Museum.

Length.—7 to 8 mm.

Records.—Ithaca. Five adults reared from larvæ parasitic on young crows. "Ithaca, N. Y., Cornell University, Exp. No. 1023, sub. 272 (I. Dobrosky)."

Plath (1922, 1934), Frison (1926) and Townsend (1936) recorded *L. sarcophagina* as heavily parasitising five species of bumblebees (*Bombus auricomus*, *B. feroidus*, *B. americanorum*, *B. bimaculatus*, and *B. vagans*).

Oppiopsis Townsend

1915. Townsend, Proc. Biol. Soc. Wash., vol. 28, p. 20.

1916. Aldrich (*Harbeckia*), *Sarcophaga* and Allies, p. 47.

1918. Townsend, Proc. Ent. Soc. Wash., vol. 20, p. 20.

The genus was erected by Townsend (1915) and in 1918 he pointed out that *Harbeckia* Aldrich was synonymous. A single species *Oppiopsis sheldoni* has been taken on Long Island.

Genotype.—*Oppiopsis sheldoni* (Coq.).

Oppiopsis sheldoni Coq.

1898. Coquillett (*Brachycoma sheldoni*), Can. Ent., vol. 30, p. 233.

1915. Townsend (*Oppiopsis sheldoni* Coq.), Proc. Biol. Soc. Wash., vol. 28, p. 20.

1916. Aldrich (*Harbeckia tessellata*), *Sarcophaga* and Allies, p. 47.

1918. Townsend, Proc. Ent. Soc. Wash., vol. 20, p. 20.

Specimens of *O. sheldoni* have been recorded from many localities throughout the northeastern part of the United States but the species does not appear to be numerous at any one time.

Length.—6 to 8½ mm.

Record.—Babylon, July 15.

Type.—Cat. No. 4069, U. S. N. M.

Erythrandra B. & B.

1891. Brauer and Bergenstamm, Denkschr. Kais. Akad. Wiss. Wien, vol. 58, p. 368.

1897. Coquillett (*Brachycoma*), U. S. D. A. Tech. Ser. No. 7, p. 131.
1916. Townsend (*Eubrachycoma*), Ins. Ins. Men., vol. 4, p. 19.
1924. Aldrich (*Erythrandra* B. & B.), Ann. Ent. Soc. Am., vol. 17, p. 211.

Aldrich studied the type from the Vienna Natural History Museum and pointed out in 1924 that our American species which Coquillett (1897) described as *Brachycoma apicalis* belonged in the genus *Erythrandra* B. & B. This genus is represented by a single species in New York.

Genotype.—*Erythrandra picipes* B. & B.

Erythrandra picipes B. & B.

1891. Brauer & Bergensta, Denkschr. Kais. Akad. Wiss. Wien, vol. 58, p. 368.

The synonymy of this species is discussed by Aldrich (1924) in detail. Townsend (1935) states that *Eubrachycoma apicalis* C. is distinct from *Erythrandra picipes* B. & B. on the ground that *Eubrachycoma apicalis* has the third longitudinal vein bristled at least half way to first cross vein while *Erythrandra picipes* has the third longitudinal vein bristled only at the base. The specimen of *E. picipes* (det. by Aldrich) which the writer has examined from New York has the third longitudinal vein bristled only at the base.

Length.—7 mm.

Records.—Black Mt., Lake George. September.

Type.—Vienna Natural History Museum.

Johnsonia Coquillett

1895. Coquillett, Proc. Acad. Nat. Sci., vol. 47, p. 316.

Hall (1933) pointed out that the diagnostic characters of this homogeneous genus were the setulose fifth vein and the long bristles on the cheeks.

Genotype.—*Johnsonia elegans* Coq.

Johnsonia borealis Reinhard

1937. Reinhard, Bull. Brooklyn Ent. Soc., vol. 32, p. 62.

Reinhard (1937) described *Johnsonia borealis* from two female specimens which were taken in Ohio and Michigan. As the spe-

cies of this genus are nearly all southern in their distribution this was the first species of *Johnsonia* known to occur in northeastern United States. Hallock (1938) described the male of *Johnsonia borealis* and gave the additional distributional records from New York and Pennsylvania. It should be noted that this species has been found chiefly in the Upper Austral and Transition Zones.

Length.—6.5 to 10 mm.

Records.—Poughkeepsie. June to the middle of August. Figure 7.

Type.—University of Michigan Museum.

Sarcofahrtia Parker

1916. Parker, *Psyche*, vol. 23, p. 131.

1916. Aldrich (*Thelodiscus*), *Sarcophaga* and *Allies*, p. 63, 302.

The genus, *Sarcofahrtia*, was described in detail by Parker (1916). Later in the same year Aldrich (1916) redescribed the genus as *Thelodiscus* and then on page 302 of his "*Sarcophaga* and *Allies*" pointed out the synonym. Parker (1919) added three new species to the genus.

It is apparent that the genera, *Sarcofahrtia* and *Wohlfahrtia*, are closely related. Both genera have the fifth sternite of the male undivided, epaulets yellow or brownish, vestiture or back of head black, the membrane connecting the genital segments to the remainder of the abdomen is unusually short which makes it somewhat more difficult to examine the genitalia of the species in these two genera than in the case of the *Sarcophaga*. Parker (1916) pointed out this relationship.

The habits of the *Sarcofahrtia* are unknown while the *Wohlfahrtia* are parasites of man and animals and often cause human myiasis.

Genotype.—*Sarcofahrtia ravinia* Parker.

Sarcofahrtia ravinia Parker

1916. Parker, *Psyche*, vol. 23, p. 123.

1916. Aldrich (*Thelodiscus indivisus*), *Sarcophaga* and *Allies*, p. 64 and p. 302.

1919. Parker, *Ent. News*, vol. 30, p. 203.

There are numerous records of *S. ravinia* throughout New Jersey, New England states, and Quebec, Canada. Although it

has never been taken in New York it undoubtedly occurs in the state.

Length.—7 to 11 mm.

Type.—Male and female in Mass. Agr. Coll. collection.

Wohlfahrtia B. & B.

1889. Brauer and Bergenstamm, Denkschr. Kais. Akad. Wiss. Wien, vol. 56, p. 123.

1893. Brauer and Bergenstamm, Verh. Zool.-Bot. Ges. Wien, vol. 43, p. 501.

When this genus was erected by Brauer and Bergenstamm insufficient distinguishing characters were listed. As a result the validity of the genus was doubted until Aldrich (1916) stated the generic characters very clearly.

Townsend (1935) pointed out that the maggots were usually deposited on the upper lip of man and entered the nostrils, though at times occurring in the ear and at other times causing dermal myiasis.

Genotype.—*Wohlfahrtia magnifica* Walker.

Wohlfahrtia vigil Walker

1848. Walker, List of Dipterous Insects in British Museum, vol. 4, p. 831.

1895. Coquillett (*Paraphyto chittendeni*), Jour. N. Y. Ent. Soc., vol. 3, p. 105.

1895. Coquillett (*Paraphyto chittendeni*), U. S. D. A. Ent. Tech. Bull. No. 7, p. 122.

1916. Aldrich, *Sarcophaga* and Allies, p. 29.

The three rows of shining black spots on the abdomen separate this species from all other Sarcophagids found in New York.

Length.—8 to 14 mm.

Records.—Syracuse; Rochester Junction; Ludlowville; Ithaca; Lockport; Williamsville; Utica; Florida. June to August.

This fly has been recorded as a parasite attacking humans by Walker (1920, 1922, 1931), Felt (1924), Gertson (1933), Matheson (1932) and Ford (1936). Shannon (1923) and Johannsen (1926) published accounts of *W. vigil* as a parasite of young rabbits. Kingscote (1932) gave an account of *W. vigil* causing

myiasis in young fox and mink which resulted in considerable loss in Canada.

Walker (1937) gave a careful description of the immature stages of *W. vigil*.

Type.—Male in British Museum.

Hypopelta Aldrich

1916. Aldrich, *Sarcophaga* and Allies, p. 49.

When Aldrich (1916) described the genus, *Hypopelta*, he fully listed the characters with the exception of the detailed genitalia differences. The hypopygial studies help to show that the genus is entirely distinct from other *Sarcophaginæ*. The fifth sternite has a large raised circular projection on each side of the lower part of the U. The basal apodeme tends to be circular instead of long and narrow as in the *Sarcophaga*. The plate portion of the ninth sternum is much reduced in comparison to its arms which are larger than the average *Sarcophaga*. The anterior clasper is fused for two-thirds of its length with the ninth sternum. This fusion has not been observed in the case of any other *Sarcophaginæ* examined.

Genotype.—*Hypopelta scrofa* Aldrich.

Hypopelta scrofa Aldrich

1916. Aldrich, *Sarcophaga* and Allies, p. 50.

The males of this species can be easily determined by the row of very long bristles on the anterior clasper and one long bristle on the posterior clasper. Both sexes have on each antennæ a very long, thin arista with short plumosity which extends about two thirds its length.

Length.—6 to 8 mm.

Records.—Ithaca; Owego. Figures 1 to 6 inclusive.

Type.—Male and female. Cat. No. 20491, U. S. N. M.

Metoposarcophaga Townsend

1917. Townsend, Proc. Biol. Soc. Wash., vol. 30, p. 46.

1919. Parker, Can. Ent., vol. 51, p. 154.

The external characters for separating *Metoposarcophaga* from related genera were given only briefly by Townsend when the

genus was erected. Aldrich (1916, 1930) placed the genotype, *importuna*, in the genus, *Sarcophaga*. Parker (1919) recognized *Metoposarcophaga*, described two new species, and gave a key to separate the four species placed in the genus.

The study of hypopygial structures helps to show that the genus is valid. It is unfortunate that *M. importuna* was the only species of *Metoposarcophaga* available for this study. The V of the fifth sternum, which is U-shaped in the case of *M. importuna*, is much more deeply cut than the average *Sarcophaginæ*. The ninth tergite is very large and gives the abdomen a truncate appearance. The arms of the ninth sternum are fused at the tip and more heavily chitinized than the other *Sarcophaginæ*. The internal portion of the ædeagus curves around and fuses to the arms of the ninth sternum as shown in the illustration of the ninth sternum (Fig. 11). The tip of the ædeagus has a distinct brush-like appearance on its front side. The pump sclerite is unusually large, as its diameter is twice the length of the ædeagus, and it has a definite cap on the small end (Fig. 13). All other *Sarcophaginæ* studied have a small pump sclerite when compared with the other hypopygial structures.

Genotype.—*Metoposarcophaga importuna* (Walker).

Metoposarcophaga importuna (Walker)

1848. Walker (*Sarcophaga importuna*), List Dipt. Brit. Museum, vol. 4, p. 819.
1916. Parker (*Sarcophaga pachyprocta*), Jour. N. Y. Ent. Soc., vol. 24, p. 171.
1916. Aldrich (*Sarcophaga larga*, *S. pachyprocta*), *Sarcophaga* and Allies, p. 147, 302.
1919. Parker (*M. pachyprocta*), Can. Ent., vol. 51, p. 154.
1930. Aldrich (*Sarcophaga importuna*), Proc. U. S. N. M., vol. 78, p. 15.

The large abdomen which appears truncate behind, distinguishes *M. importuna* from all other *Sarcophaginæ* which have been found in New York.

Length.—6 to 10 mm.

Records.—*L.I.*: Babylon; Heckscher State Park; Dix Hills; Long Beach; Sands Point; Oak Island. May to August. Figures 8 to 13 inclusive.

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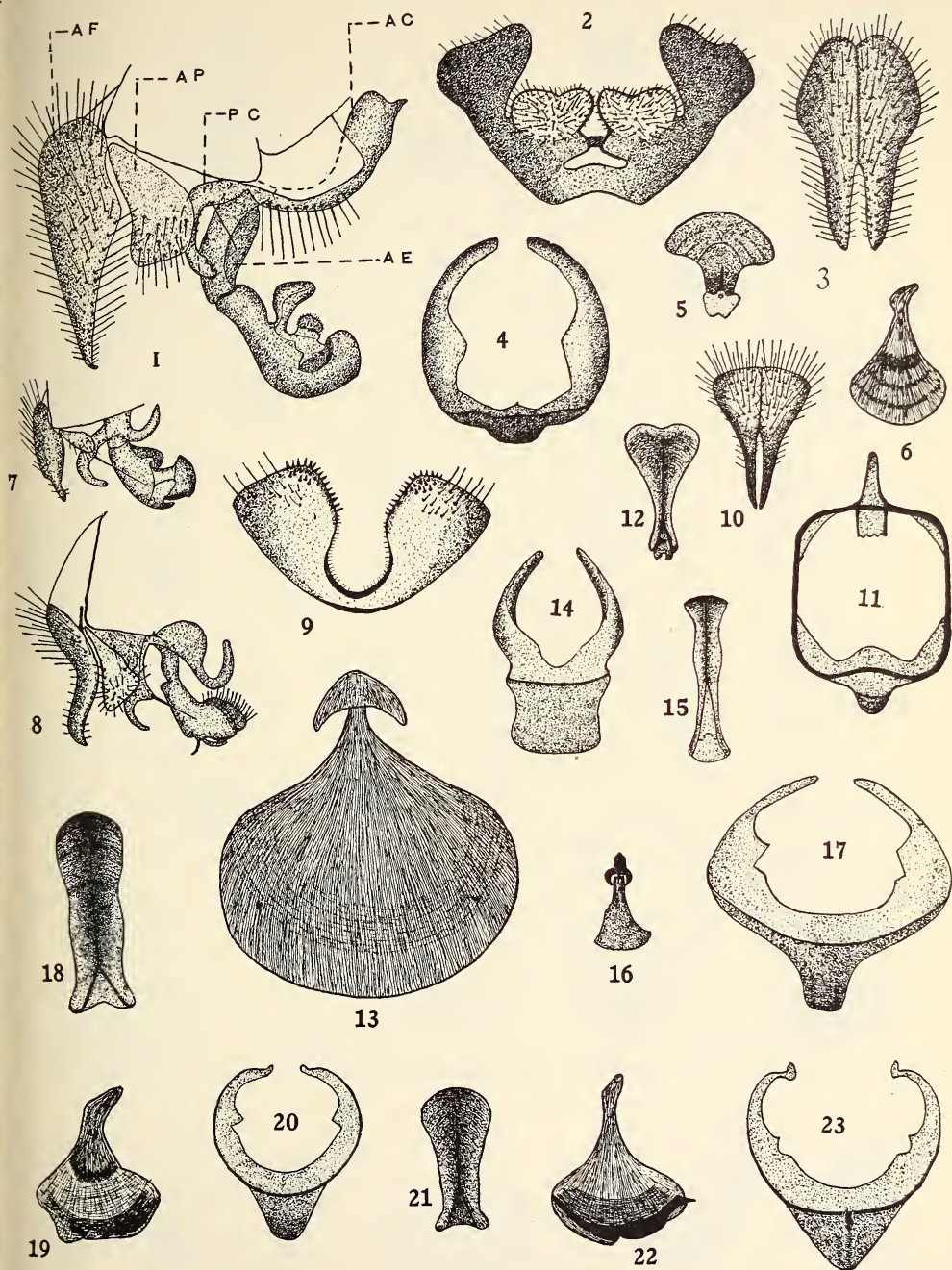
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PLATE II

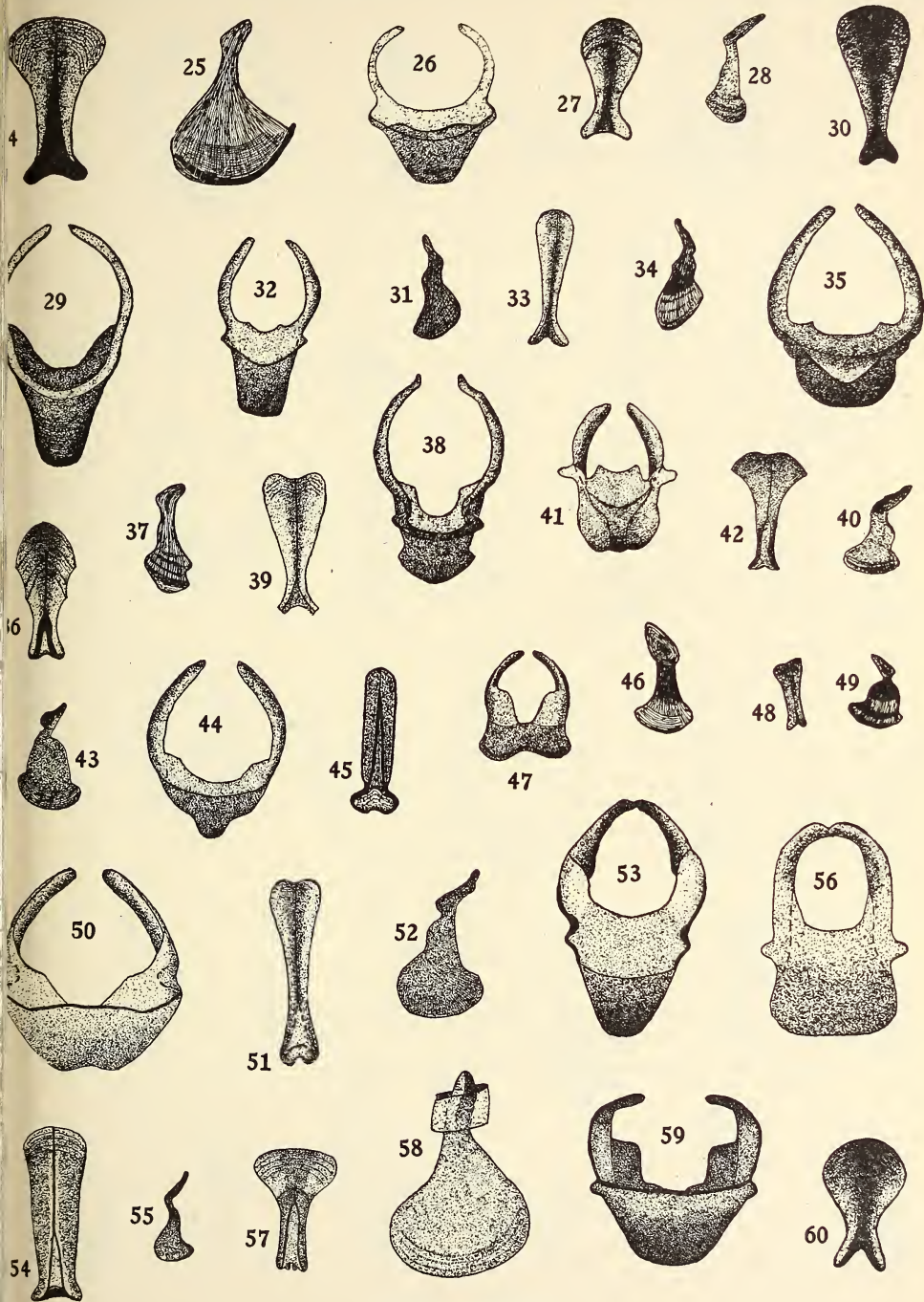
- Figure 1. Lateral view of external genitalia of *Hypopelta scrofa*.
Figure 2. Fifth sternum of *Hypopelta scrofa*.
Figure 3. Rear view of anal forceps of *Hypopelta scrofa*.
Figure 4. Ninth sternum of *Hypopelta scrofa*.
Figure 5. Basal apodeme of *Hypopelta scrofa*.
Figure 6. Pump sclerite of *Hypopelta scrofa*.
Figure 7. Lateral view of external genitalia of *Johnsonia borealis*.
Figure 8. Lateral view of external genitalia of *Metoposarcophaga importuna*.
Figure 9. Fifth sternum of *Metoposarcophaga importuna*.
Figure 10. Rear view of anal forceps of *Metoposarcophaga importuna*.
Figure 11. Ninth sternum of *Metoposarcophaga importuna*.
Figure 12. Basal apodeme of *Metoposarcophaga importuna*.
Figure 13. Pump sclerite of *Metoposarcophaga importuna*.
Figure 14. Ninth sternum of *Sarcophaga misera* var. *sarracenioides*.
Figure 15. Basal apodeme of *Sarcophaga misera* var. *sarracenioides*.
Figure 16. Pump sclerite of *Sarcophaga misera* var. *sarracenioides*.
Figure 17. Ninth sternum of *Sarcophaga bisetosa*.
Figure 18. Basal apodeme of *Sarcophaga bisetosa*.
Figure 19. Pump sclerite of *Sarcophaga bisetosa*.
Figure 20. Ninth sternum of *Sarcophaga cimbicis*.
Figure 21. Basal apodeme of *Sarcophaga cimbicis*.
Figure 22. Pump sclerite of *Sarcophaga cimbicis*.
Figure 23. Ninth sternum of *Sarcophaga latisterna*.



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PLATE III

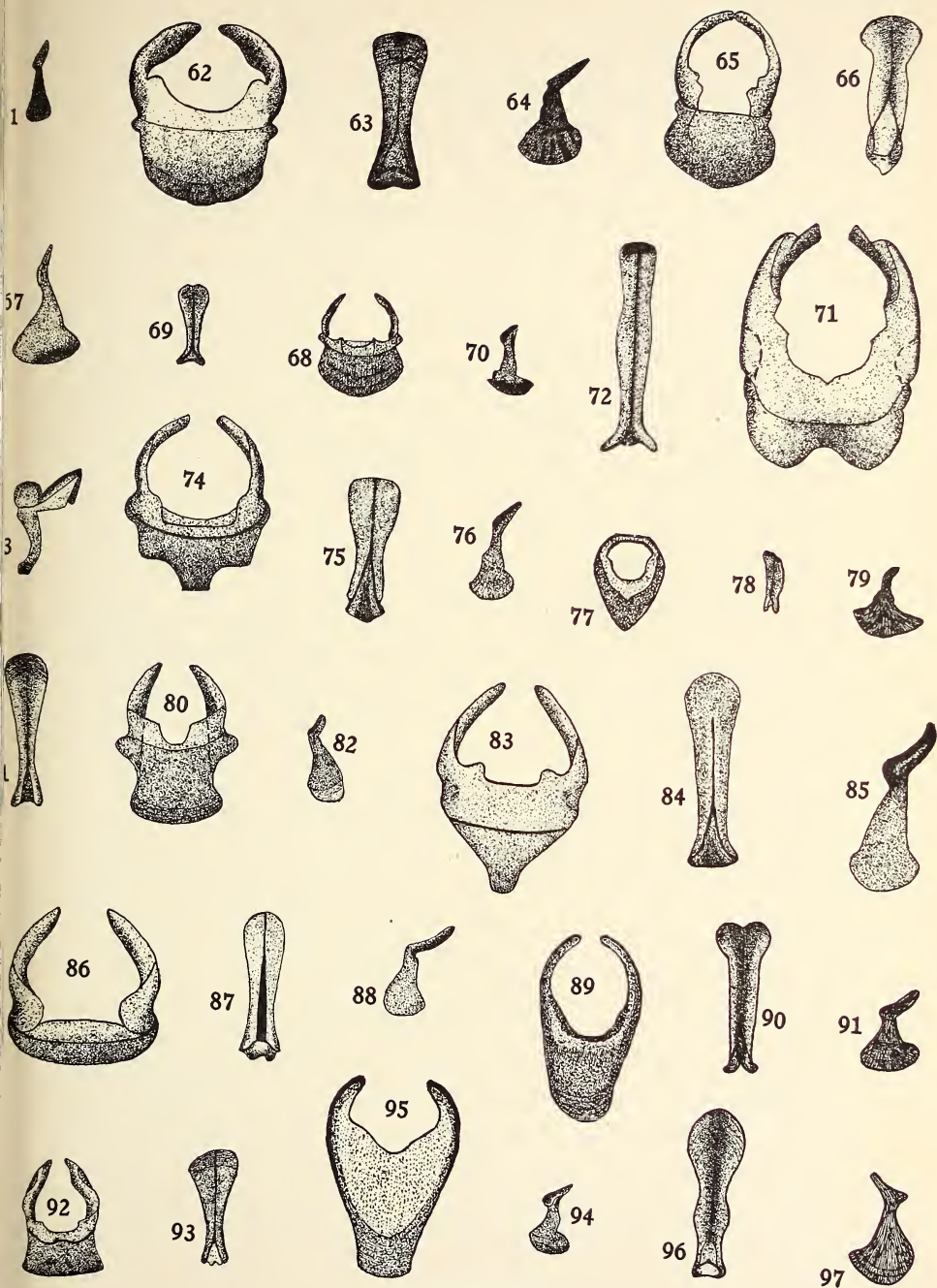
- Figure 24. Basal apodeme of *Sarcophaga latisterna*.
Figure 25. Pump sclerite of *Sarcophaga latisterna*.
Figure 26. Ninth sternum of *Sarcophaga latisetosa*.
Figure 27. Basal apodeme of *Sarcophaga latisetosa*.
Figure 28. Pump sclerite of *Sarcophaga latisetosa*.
Figure 29. Ninth sternum of *Sarcophaga l'herminieri*.
Figure 30. Basal apodeme of *Sarcophaga l'herminieri*.
Figure 31. Pump sclerite of *Sarcophaga l'herminieri*.
Figure 32. Ninth sternum of *Sarcophaga pusiola*.
Figure 33. Basal apodeme of *Sarcophaga pusiola*.
Figure 34. Pump sclerite of *Sarcophaga pusiola*.
Figure 35. Ninth sternum of *Sarcophaga stimulans*.
Figure 36. Basal apodeme of *Sarcophaga stimulans*.
Figure 37. Pump sclerite of *Sarcophaga stimulans*.
Figure 38. Ninth sternum of *Sarcophaga sueta*.
Figure 39. Basal apodeme of *Sarcophaga sueta*.
Figure 40. Pump sclerite of *Sarcophaga sueta*.
Figure 41. Ninth sternum of *Sarcophaga alcedo*.
Figure 42. Basal apodeme of *Sarcophaga alcedo*.
Figure 43. Pump sclerite of *Sarcophaga alcedo*.
Figure 44. Ninth sternum of *Sarcophaga aldrichi*.
Figure 45. Basal apodeme of *Sarcophaga aldrichi*.
Figure 46. Pump sclerite of *Sarcophaga aldrichi*.
Figure 47. Ninth sternum of *Sarcophaga atlantis*.
Figure 48. Basal apodeme of *Sarcophaga atlantis*.
Figure 49. Pump sclerite of *Sarcophaga atlantis*.
Figure 50. Ninth sternum of *Sarcophaga barbata*.
Figure 51. Basal apodeme of *Sarcophaga barbata*.
Figure 52. Pump sclerite of *Sarcophaga barbata*.
Figure 53. Ninth sternum of *Sarcophaga bullata*.
Figure 54. Basal apodeme of *Sarcophaga bullata*.
Figure 55. Pump sclerite of *Sarcophaga bullata*.
Figure 56. Ninth sternum of *Sarcophaga flavipalpis*.
Figure 57. Basal apodeme of *Sarcophaga flavipalpis*.
Figure 58. Pump sclerite of *Sarcophaga flavipalpis*.
Figure 59. Ninth sternum of *Sarcophaga fletcheri*.
Figure 60. Basal apodeme of *Sarcophaga fletcheri*.



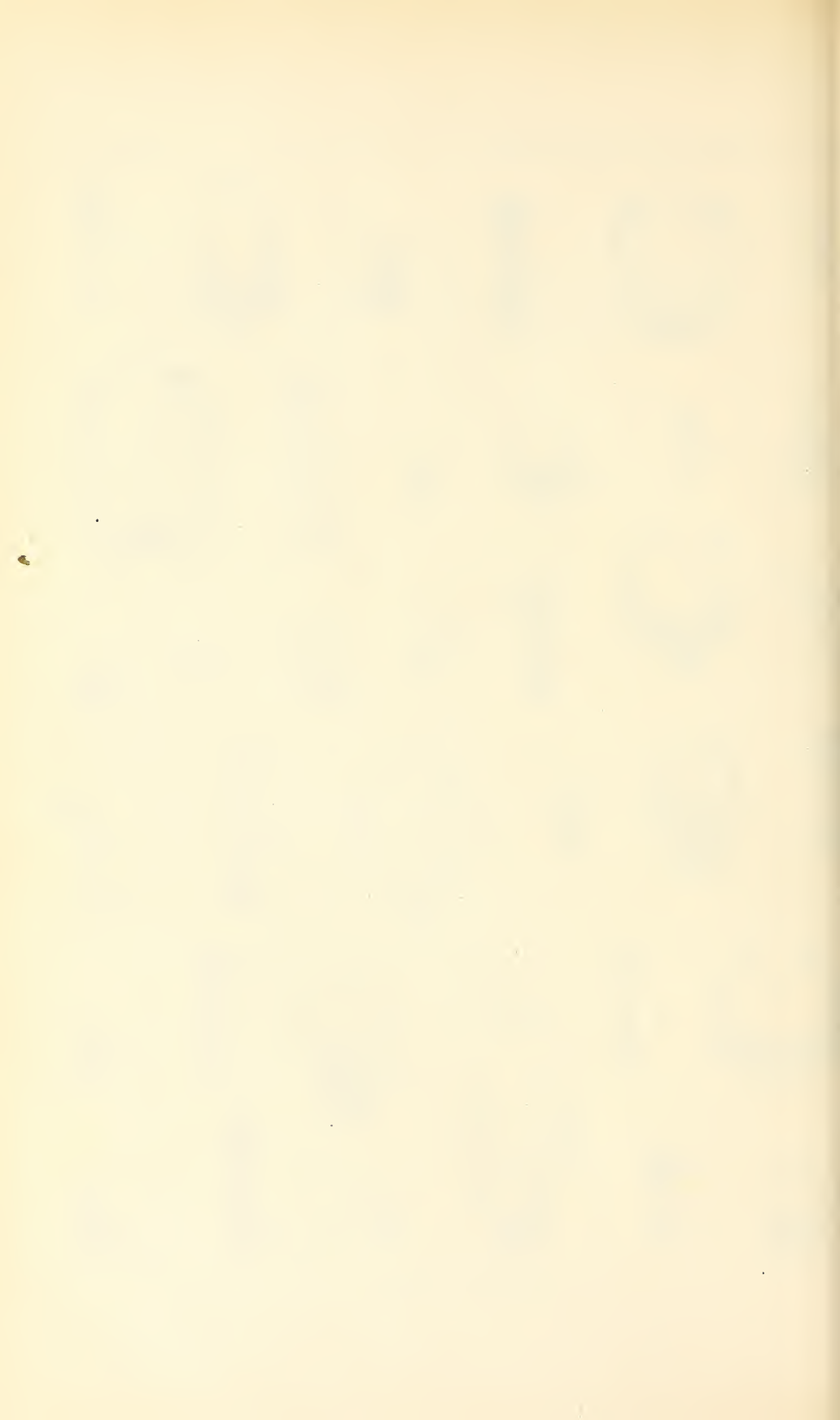
SARCOPHAGINÆ

PLATE IV

- Figure 61. Pump sclerite of *Sarcophaga fletcheri*.
Figure 62. Ninth sternum of *Sarcophaga hæmorrhoidalis*.
Figure 63. Basal apodeme of *Sarcophaga hæmorrhoidalis*.
Figure 64. Pump sclerite of *Sarcophaga hæmorrhoidalis*.
Figure 65. Ninth sternum of *Sarcophaga houghi*.
Figure 66. Basal apodeme of *Sarcophaga houghi*.
Figure 67. Pump sclerite of *Sarcophaga houghi*.
Figure 68. Ninth sternum of *Sarcophaga hunteri*.
Figure 69. Basal apodeme of *Sarcophaga hunteri*.
Figure 70. Pump sclerite of *Sarcophaga hunteri*.
Figure 71. Ninth sternum of *Sarcophaga johnsoni*.
Figure 72. Basal apodeme of *Sarcophaga johnsoni*.
Figure 73. Pump sclerite of *Sarcophaga johnsoni*.
Figure 74. Ninth sternum of *Sarcophaga parallela*.
Figure 75. Basal apodeme of *Sarcophaga parallela*.
Figure 76. Pump sclerite of *Sarcophaga parallela*.
Figure 77. Ninth sternum of *Sarcophaga rapax*.
Figure 78. Basal apodeme of *Sarcophaga rapax*.
Figure 79. Pump sclerite of *Sarcophaga rapax*.
Figure 80. Ninth sternum of *Sarcophaga reversa*.
Figure 81. Basal apodeme of *Sarcophaga reversa*.
Figure 82. Pump sclerite of *Sarcophaga reversa*.
Figure 83. Ninth sternum of *Sarcophaga scoparia* var. *nearctica*.
Figure 84. Basal apodeme of *Sarcophaga scoparia* var. *nearctica*.
Figure 85. Pump sclerite of *Sarcophaga scoparia* var. *nearctica*.
Figure 86. Ninth sternum of *Sarcophaga securifera*.
Figure 87. Basal apodeme of *Sarcophaga securifera*.
Figure 88. Pump sclerite of *Sarcophaga securifera*.
Figure 89. Ninth sternum of *Sarcophaga sinuata*.
Figure 90. Basal apodeme of *Sarcophaga sinuata*.
Figure 91. Pump sclerite of *Sarcophaga sinuata*.
Figure 92. Ninth sternum of *Sarcophaga uncata*.
Figure 93. Basal apodeme of *Sarcophaga uncata*.
Figure 94. Pump sclerite of *Sarcophaga uncata*.
Figure 95. Ninth sternum of *Sarcophaga ventricosa*.
Figure 96. Basal apodeme of *Sarcophaga ventricosa*.
Figure 97. Pump sclerite of *Sarcophaga ventricosa*.



SARCOPHAGINÆ



STUDIES ON THE ICHNEUMONIDÆ OF NEW
ENGLAND (HYMENOPTERA)PART 1¹THE EXTERNAL MORPHOLOGY OF *AROTES AMÆNUS* CRESSON

BY HARRY D. PRATT

INTRODUCTION

The ichneumon-flies make up unquestionably the largest and most extensive family in the order Hymenoptera, and it is composed of a vast number of minor groups, representing hundreds of genera and thousands of species in North America alone. Unlike other families, the ichneumon-flies, without a single exception, are all genuine parasites, and destroy or devour the eggs, larvæ, pupæ, or imagoes of other insects. Almost every insect, whose biology is known, has at least one ichneumonoid parasite, and the more important economic insects (as the gypsy and browntail moths) have dozens of ichneumon-fly parasites. The family is, therefore, of the greatest economic importance from the viewpoint of biological control, and in some cases, as with the Oriental fruit moth, parasitic control is the only practical type that is used.

Arotes amænus Cresson was chosen as the subject of this study because it is common throughout New England, so that an abundance of material could be collected for study. It is one of the larger and more primitive of the ichneumon-flies and, for this reason, is well-suited for such a study.

One of the greatest difficulties in the study of the systematic groups is the lack of uniformity in the terminology used to describe the various morphological features of the insects concerned. This fact is especially noticeable in the descriptions of the Ichneumonidæ when one attempts to use the keys of Asmead, Schmiedeknecht, or some of the other nineteenth century taxonomists, whose descriptions are based either on a purely artificial system of terminology (as is the case in the naming of the wing

¹ Thesis submitted in partial fulfillment for the degree of Master of Science in 1938 at the Massachusetts State College, Amherst, Massachusetts.

veins according to the Cressonian system), or on a system containing a great many incorrect terms (as is the case in the misapplication of the terms "prothorax," "postscutellum," "metanotum," and "metatarsus."

The great advances which have been made in comparative morphology have made it not only wholly unnecessary, but highly undesirable, to continue such a type of taxonomic work. The following detailed, purely morphological study of one species has been made to serve as a basis for future taxonomic work, and it is hoped that this study will be an aid in determining the morphological status of many structures which have heretofore been misnamed, and in clarifying the terminology used in describing the ichneumon-flies.

The writer wishes to express his indebtedness for the invaluable help given by Dr. G. C. Crampton in the morphological study. To Dr. J. C. Bradley and to Dr. Herbert H. Ross the writer wishes to express his appreciation for their help in the study of the wing venation; and to Dr. Richard Holway for his help in the study of the pretarsus. To Dr. C. P. Alexander the writer is indebted for his constant enthusiasm and kindly criticism throughout the course of this research.

THE HEAD

The head of the male is slightly more than two-thirds the size of that of the female, and its features are less strongly developed than are those of the female. When viewed from in front, the head appears somewhat broader than long and is flattened dorsally along the parietals. In lateral aspect the compound eyes appear to be of almost exactly the same width as the gena. The sutures which demark the areas of the cranium in a typical orthopteroid insect have become obsolescent in *Arotes*, so that the head is remarkable for its lack of sutures. Two of these sutures, the occipital and hypostomal, have been replaced, however, by distinct carinae which are of great importance in bounding the sclerites of the head.

HEAD CAPSULE

The principal areas of the cranium (Fig. 1) are the *dorsal parietals*, the median facial, or *fronto-clypeal* area, the lateral

genæ, the *occipital arch* (composed of the *occiput* and *postgenæ*) and *post-occiput* surrounding the *foramen magnum*, and the narrow *hypostomal* areas upon which the mouth-parts articulate.

The *parietals* and *fronto-clypeal* areas extend cephalad from the occipital carina between the compound eyes to a line drawn between the *anterior tentorial pits*. The *parietals* (pa) (Fig. 1) include the dorsal surface of the epicranium between the occipital carina and the antennal sclerites, with the exception of the post-frons which is a more or less pentagonal area extending caudad from the antennal sclerites to the median ocellus, as will be explained in greater detail in the discussion of the frons.

The *frons* (af and pf) is a median unpaired sclerite extending from the two anterior tentorial pits to, and including, the median ocellus. According to Crampton (1921), "When the frontal suture is absent, if a line be drawn across from the top of one antennal fovea to the other, and at either end of this line an angle of forty-five degrees is constructed, the sides of the isosceles triangle thus formed correspond in a general way to the Y-shaped epicranial suture." In *Arotes* these antennal foveæ are rather deep depressions which serve for the reception of the scape of the antenna when the antennæ are curved back over the body. These foveæ extend caudad almost as far as do the eyes, and then the frons narrows quite rapidly so as to include the median ocellus.

Because of the noticeable constriction of the frons at the antennæ, Crampton (1921) divides the frons by a line drawn between the bases of the antennæ into an *antefrons* (af) and a *postfrons* (pf). In *Arotes amænus* such a line occurs naturally, appearing as a darkly-colored hair line extending to the middle of each antennal sclerite, from the distinct carina on the middle of the post-frons. Therefore the *postfrons* (pf) is a roughly pentagonal area extending caudad to the median ocellus, while the *antefrons* (af) is a more or less quadrangular area extending cephalad to the anterior tentorial pits.

For taxonomic purposes, the morphological *antefrons* extending caudad to the base of the antennæ might well be called the "frons." Similarly, the whole dorsal surface of the head could be called the "vertex," since the *postfrons* merges completely with the *parietals* and the epicranial suture has also disappeared

doing away with the necessity of the term "parietals" which should be used for the paired dorsal sclerites. Therefore, for taxonomic purposes in Ichneumonidæ, it would seem best to use but two terms, "vertex" and "frons," for the frontal aspect of the head, and to use the antennæ as the line of division: the dorsal part above the antennæ, the "vertex"; the ventral part below the antennæ, the "frons."

On either side of the true *antefrons* (af) lie the areas known as the *parafrontals* (paf). These extend caudad to the antennal sclerites, cephalad to the base of the mandibles, and laterad to the *ocular sclerites* (asc) and the *subocular suture* (sos). Taxonomically the parafrontals, known as the "inner orbits," are important in specific determinations.

The narrow space separating the compound eye from the base of the mandible, known taxonomically as the "malar space," is a very important character in both generic and specific determinations because its length in relation to the basal width of the mandible is constant. Cushman (1920) calls the *subocular suture*, which arises from the ventral margin of the ocular sclerite and extends ventrad to the dorsal articulation of the mandible, the "malar suture."

The *compound eyes* are large and convex, with their inner margins parallel and not emarginate within, or only very slightly so opposite the antennæ. Their surface is reticulate, being composed of the hexagonal facets of the large number of ommatidia. They are surrounded by narrow, poorly-demarcated, elliptical *ocular sclerites* (osc) which extend shelf-like into the head capsule. These chitinous ingrowths appear lens-shaped and are pierced in the middle by a foramen through which the optic nerves pass connecting the optic lobes with the nerve endings of the ommatidia.

The endoskeleton of the head, which braces the lower portion of the head capsule, is called the *tentorium*. In *Arotes* two pair of cuticular invaginations, known respectively as the *anterior* and *posterior* arms of the tentorium, unite within the head to form a framework arching over the ventral nerve cord, but passing beneath the stomodæum and supporting the latter. The *body* of the tentorium, formed by the fusion of the anterior and poste-

rior arms, is not clearly demarked and seems to be composed only of that portion of the tentorium immediately cephalad of the foramen. The *anterior arms* arise from the *anterior tentorial pits*. Each *anterior arm* extends caudad as a long arched chitinous bar to the body of the tentorium, and serves for the attachment of the muscles moving the mouth-parts. The *posterior arms* arise as short invaginations of the hypostomal region, one on each side of the midgular suture. They are barely distinguishable as short chitinous bars before they fuse into the body of the tentorium which lies immediately cephalad of the foramen. The *dorsal arms* are secondary outgrowths of the anterior arms and are strongly developed in *Arotes*. They extend cephalad from the anterior arms to the lateral portions of the antennal sclerites, and serve as points of attachment for the antennal muscles.

The *anterior tentorial pits* (at) (frontal pits of Crampton, 1921) are well defined depressions that outwardly mark the two points from which the anterior arms of the tentorium arise. As determined by a study of the ental surface, the lateral prolongations of these arms extend obliquely ventrad to the base of the mandibles as a pair of lines demarking the clypeus within, but as in most parasitic Hymenoptera (see Snodgrass, 1935, p. 297), these "bars are not connected between the pits." Posteriorly, these epistomal bars are continued externally as strong marginal ridges, differentiated into a *pleurostoma* (plst) bearing the mandibular articulations, and a *hypostoma* (hp) supporting the maxillæ and labium. In the discussion that follows, the pleurostoma is considered as the ventral portion of the gena; while the hypostoma is considered as a separate hypostomal area originally derived from the postgenæ.

The *clypeus* (cl), which is a flat, trapezoidal area extending cephalad from the anterior tentorial pits to the base of the mandible, is bounded laterally by a line drawn from these depressions to the base of the mandible. The clypeus is slightly inflexed at the apex, but since there are no distinct sutures or carinæ, nor any ental thickenings, it is rather difficult to divide it satisfactorily into a postclypeus and an anteclypeus. Taxonomists usually describe the clypeus as "truncate," but specimens boiled in potassium hydroxide and examined under high magnifi-

cation show that the clypeus is shallowly emarginate with a slight median projection, as is shown in the figure.

The *genæ* (ge) are long, rounded sclerites beneath and behind the eyes and are of about the same width as the compound eyes when seen from a lateral viewpoint. They are not demarked from the parietals but may be said arbitrarily to begin on a line drawn from the most dorsal point of the compound eyes to the occipital and hypostomal carinæ, and to extend anteriorly to the base of the mandible and the subocular suture. The ventral part of the *genæ*, therefore, is the *pleurostoma* (plst) (Fig. 2) of Snodgrass (1935). Just laterad of the subocular suture is a short, blunt tooth forming the *pleurostomal condyle*, or the cranial portion of the *dorsal articulation* of the mandible. Immediately posterior to this tooth is a distinct emargination and elevation of the chitin. Careful examination with high magnification reveals that there is a corresponding elevation on the mandible, while in between the two lies the slender extensor muscle which opens the mandibles. The reason for this outpouching of the chitin will be explained in the discussion of the mandible. Many taxonomists call the *genæ* the "cheeks" or the "outer or posterior orbits." The coloration and striation of the *genæ* is much used in the separation of subgeneric groups and species of Ichneumonidæ.

The *occipital arch*. On the postero-caudal surface of the head (Fig. 2), between the occipital carina and the postoccipital suture, is a horseshoe-shaped sclerite called the occipital arch. Although there is no suture dividing it, the occipital arch is generally said to be composed of a dorsal part, the *occiput* (oc), and the ventro-lateral extensions of this, lying posterior to the *genæ*, called the *postgenæ* (pg).

The narrow posterior rim surrounding the foramen and demarked from the occiput by a *post-occipital suture* (pcs) is called the *post-occiput* (pc). Snodgrass (1935, p. 112) suggests that, "The post-occiput probably is a sclerotic remnant of the labial segment." If this statement is true, then the postocciput is the only sclerite entering into the composition of the head to retain the primitive Annelid alignment.

In *Arotes*, since there is no subgenal suture, it seems best to consider the subgenal area as the *hypostomal area* composed of

the narrow marginal area on the sides of the cranium upon which the mouth-parts are articulated and demarked posteriorly by the *hypostomal carina* (hpc). The postgenal region of the cranium has become greatly elongated, thereby creating a long space between the foramen magnum and the base of the mandibles and, at the same time, displacing the labium ventrally by mesal outgrowths of the subgenæ, called the *hypostomal bridge*, so that the bases of the labium and the maxillæ have become united into a labio-maxillary complex. According to Snodgrass (1935) the hypostomal bridge consists of "expansions of the hypostomal parts of the subgenal margin of the cranium and each is separated by a distinct carina from the corresponding postgenal region."

The *hypostomal carina* (hpc) starts at the base of the mandible mesal to the mandibular condyle, and extends posteriorly joining onto the occipital carina and then curving inward towards the foramen where it finally ends on the *midgular suture* determined by the posterior arms of the tentorium. Due to the approximation of the posterior arms of the tentorium on the ventral margin of the foramen, the gula itself has become atrophied and is represented only by the midgular suture.

APPENDAGES OF THE HEAD

The appendages of the head include the antennæ, labrum, mandibles, maxillæ, and labium. Just as the characteristic feature of the head capsule of *Arotes* is the development of the hypostomal bridge, so the characteristic feature of the mouth-parts is the close association or union of the maxillæ, the labium, and the hypopharynx to form the underlip complex, in which the ligula and hypopharynx are combined in a median lobe on which the salivary ducts open.

Each *antenna* (Fig. 4) is composed of about forty segments and may be divided into three principal parts. The first and largest segment, by which the antenna is attached to the head, is termed the *scape* (sep). Externally it has somewhat the shape of a funnel with flaring sides, cut diagonally across the top; internally, it expands into a basal bulb so that the antenna articulates with the *antennal sclerite* (as) by a ball and socket joint

allowing free movement in all directions. The basal bulb has an opening through which run the muscles moving the scape. These muscles have their origin on the dorsal arm of the tentorium, while other muscles arising on the base of the pedicel, move the pedicel and flagellum together, thus controlling the movements of the antennæ. The *pedicel* (pdc), or second segment, is quite short and is sometimes almost hidden from sight, so deeply is it inserted in the scape. The remainder of the antenna is collectively termed the *flagellum* (fl) or *clavola*. The reason for considering the greater part of the antenna as one of the three principal divisions has been explained by Snodgrass (1935, p. 132) who wrote, "Since the flagellar divisions in Orthopteroid insects increase in number from one instar to the next, they appear to be secondary subdivisions of one primary antennal segment." The first flagellar segment is weakly sclerotized a short distance above the base, giving the effect of a very short segment suggestive of the ring-joints of Chalcidoidea and high Hymenoptera, but there is no real articulation or segmentation at this point. The basal flagellar segment is three and one half times as long as broad, and each succeeding segment is somewhat shorter than the preceding one, so that the segment preceding the terminal one is but one and one half times as long as wide. The antennæ, therefore, may be called attenuate. Note that the terminal segment is twice as long as the preceding one, due, most probably, to a fusion of the last two segments.

The *labrum* (lm) is attached (Fig. 1) to the inner surface of the clypeus by membrane and projects below it as a semicircular sclerite. A study of the inner surface of the clypeus reveals that the labrum is attached to the clypeus at about its middle dorso-ventrally. The posterior limits of the labrum seem to be determined by membranous thickenings which have their origin just mesad of the dorsal articulations of the mandibles. These membranes curve posteriorly a short distance, paralleling the epistomal bars, and then converge medially and ventrally on the clypeus to form the *epipharynx*, a flexible, triangular membranous lobe which projects below the labrum as a short, sharp, pointed protuberance about as long as the dorsal and outer tooth of the mandibles. Along the apical margin of the labrum, on both the

inner and outer surfaces, are a few long hairs which may be sensory in nature.

The *mandibles* (md) (Fig. 7) are placed just behind the epipharynx, one on each side of the mouth opening. They are of medium size, somewhat curved, and taper apically ending in two blunt teeth, of which the ventral one is the longer, being half again as long as the outer and dorsal tooth. Each mandible has two principal articulations with the head capsule; an *anterior*, or *dorsal articulation*, and a *posterior*, or *ventral articulation*. Both of these are of the "ball and socket" type of joints. The *dorsal articulation* consists of a *pleurostomal condyle* situated just laterad of the *subocular suture* which fits into a shallow socket, or ginglymus, on the mandible. The *ventral articulation* consists of a deep socket on the pleurostomal region of the gena, just cephalad of the hypostomal carina, and *mandibular condyle* (hypocondyle of Crampton, 1921) which fits into this socket. Each mandible is moved by two muscles: an *extensor* or *abductor* muscle which opens the mandible; and a *flexor* or *adductor* muscle which closes the mandible. The *extensor* muscle is relatively small. It is inserted on a chitinous outpouching of the outer face of the mandible between the dorsal socket and the ventral condyle. The outer and anterior face of the mandible is almost flat between the two articulations and parallels the axis line between the two so closely that this outpouching is necessary in order that the base of the extensor muscle be placed sufficiently far outside the axis line to give effectiveness as a muscle. The insertion of the extensor muscle is contiguous to the anterior articulation of the mandible, but it is twice its width from the posterior articulation. The *flexor* muscle is huge and is composed of several bundles of fibers inserted on a large apodeme attached at the inner angle of the mandible almost posterior to the anterior articulation. When not in use the tip of one mandible extends over and covers the tip of the other. There seems to be no special arrangements as to which is outer, for, in specimens examined, the right seemed to cover the left as often as the left covered the right.

The labio-maxillary complex of *Arotes* is attached to the posterior wall of the head between the postgenal margins of the cra-

nium by ample membranes, which allow it free movement on the suspensoria formed by the maxillary cardines. As explained by Snodgrass (1935) a line of flexure crosses the posterior part of this complex through the stipito-cardinal sutures of the maxilla. The basal portion composed of the cardines is bent abruptly toward the head, where it is attached; and the distal portion composed of the labium and the body of the maxillæ lies parallel with the ventral surface of the head. The entire organ can thus be extended by swinging distally on the maxillary cardines. The maxillæ lie one on each side of the labium and are connected to it by the membranous submental area and by maxillary membranes.

Maxillæ (Fig. 6). In each maxilla the *cardo* (cd) is a heavily sclerotized sclerite, somewhat triangular in shape, which tapers to the base and is bent entally. Its extreme base is modified to form two processes which articulate deep in the head capsule with two arm-like projections of the hypostomal bridge, one on each side of the midgular suture. There is apparently no cardo-condyle by which the cardo articulates with the post-genal area, but the whole maxilla is capable of some movement due to the concavity of the hypostomal area and the convexity of the cardo and stipes. The *cardo* (cd) articulates with the *stipes* (st) by means of a distinct membranous hinge, and their planes form a distinct angle at the union. The *stipes* (st) is the broad and elongate sclerite forming the body of the maxilla. On its ventral surface is a distinct carina, or ridge, extending diagonally across the stipes from the cardo to the *palpus* (mxplp). There is no trace of the parastipital area. The 5-segmented *palpus* (mxplp) is inserted latero-ventrally on the distal end of the stipes. Just distal to the base of the palpus is attached a large, fleshy lobe called the *galea* (ga), which is distinctly hollowed out for the reception of the lacinia. The *lacinia* (la), which is hinged to the distal end of the stipes, is a large, flat, weakly sclerotized lobe with two slight tooth-like expansions (as is shown in Fig. 6).

Labium (Fig. 5). The labium (lb) is composed of a membranous *submental region* (smt) and a distal *prementum* (prmt) bearing the palpi, glossa, and paraglossæ. The submentum is not sclerotized and probably is situated in the membranous re-

gion attached posteriorly to the stipes at the cardostipital suture and extending anteriorly about two-thirds of the length of the stipes. The *prementum* (prmt) (*mentum* of many authors) is a large, strongly convex, heavily sclerotized plate, the basal and lateral portions of which are strongly produced and bent over so as to extend dorsally to meet the hypopharynx which is situated on the dorsal surface of the labium. The *prementum* (prmt) is expanded centrally and is very convex, sloping abruptly to the glossæ beyond. At about the middle of the prementum are attached the 4-segmented *labial palpi* (laplp) which are only about as long as the first three segments of the maxillary palpi and are much shorter and somewhat more slender than the latter. The *glossa* (gl) is a large, bilobed, membranous pad attached to the distal portion of the prementum. Its apical margin is covered with short, plush-like hair, while the rest of the glossa lacks this covering. The ventral surface of the glossa lacks this covering. The ventral surface of the glossa seems to be longitudinally striate throughout, but the dorsal surface is transversely striate on the distal two-thirds and is smooth and rather heavily sclerotized on the basal third. On either side of this narrow sclerotized base of the glossa occurs a small membranous pad, very similar in structure to the glossa, and these pads apparently represent the *paraglossæ* (pgl). These paraglossæ are closely appressed to the prementum and are best seen from the dorsal view. Viewed from below, they appear as membranous lobes dorsal and cephalad to the palpi (Fig. 6). A membranous papilla-like protuberance, which is the *hypopharynx*, occurs on the median line of the dorsal surface of the prementum just caudal to the base of the glossa. The identity of the hypopharynx is determined by the presence of the opening of the salivary duct at the base of this distinct papilliform protuberance.

NECK OR CERVIX

The neck or cervix connects the head with the thorax and covers the antero-ventral region of the thorax. It is composed of a single pair of plates known as the *lateral cervicals* (lc) (Fig. 9) which articulate with the head by means of the *cephaligers* and with the coxæ by a coxal process.

The *lateral cervicals* (lc) are broad, truncate sclerites, tapering from base to apex, and are joined with membrane along the median line. As shown by Crampton (1926), each lateral cervical results from the fusion of the enlarged lateral cervical, the proepisternum, and the proepimeron; while the prosternum, for which the lateral cervicals have so frequently been mistaken, is represented by a tiny plate partially concealed between the coxæ.

At the anterior end of the lateral cervicals, the *cephaligers* arise on the inner surface and enlarge into knob-like projections which are the actual fulcral points of the head with the cervix.

A blunt, tooth-like projection, which is called the *coxal process*, is found on the ental surface of each lateral cervical near the lateral posterior angle of the sclerite and this projection forms a part of the apparatus for the attachment of the coxa of the fore leg.

THORAX

PROTHORAX

In *Arotes* the prothorax (Fig. 9) consists largely of the *pronotum* (N_1) for the propleura have fused with the lateral cervicals, as explained before in the discussion of the cervix, and the prosternum is reduced to a tiny sclerite lying between the coxæ.

The *pronotum* (N_1) is a narrow transverse plate produced laterally and posteriorly into distinct, triangular lobes which extend posteriorly to the tegulæ, and ventrally to the bases of the fore coxæ. The anterior margin of the pronotum is broadly emarginate, while the posterior margin is arcuately emarginate and overlaps the front margin of the prescutum of the mesothorax (psc_2).

The *prosternum* is a small sclerite composed of an anterior *basisternum* and a posterior *furcasternum*. The triangular basisternum seems to send chitinous processes to the basal end of the lateral cervicals, while the furcasternum forms a broad rounded lobe between the fore coxæ and is the base to which the sternal apophyses of the endoskeleton of the prothorax are attached.

MESOTHORAX

The tergum of the mesothorax (9) is divided into a prescutum, scutum, scutellum, and parascutellum.

The *prescutum* (pse_2) is the large, arched, anterior plate of the tergum which extends cephalad under the pronotum and there gives rise to the prephragma of the mesothorax. It is separated from the scutum by the *notaulices* (usually called the *notauli* by systematists and variously called the V-shaped suture, convergent sutures, or the parapsidal sutures by morphologists).

The *scutum* (sc_2) is the large, rather convex plate rather definitely divided by the notaulices into two lateral portions sometimes called the *parapsides*, to which the *tegulae* and the wings are attached. Behind the scutum lies the scutellar fovea which is twice as long and contains several indistinct longitudinal carinae along its middle.

The *scutellum* (sc_2) is twice as long as this scutellar fovea and is connected with the scutum by a chitinous bar on each end of the fovea. Its apex is truncate. The *postscutellum* is hidden beneath the scutellum, where it is fused with the endoskeleton of the mesothorax.

The *parascutellum* consists of two triangular plates extending from the scutum and scutellum to the wing bases, where they form the posterior margin of the fore wing base and the anterior margin of the hind wing base.

The mesepisternal and mesosternal plates are fused into a single sterno-pleural plate making the identification of the lateral and sternal plates rather difficult. Snodgrass (1910) states that the "mesopectus consists of three principal plates, the combined sternum and episterna, and the two epimera."

The mesepisternum and mesepimeron were originally separated by a *pleural suture* corresponding to the strong, internal pleural ridge, forming the wing process above and the coxal process below. In *Arotes* this suture is represented by a row of small, pit-like depressions similar to those in *Trogus* which are well shown in the fine figures by Snodgrass (1910). Although this row of punctures is scarcely recognizable as a suture, the presence of the pleural ridge directly beneath it proves that it is the pleural suture, the important landmark on the mesopleura in the division into mesepisternum and mesepimeron.

The *mesepisternum* (eps_2) is the large, more or less triangular plate forming the greater part of the mesopleura. Its anterior

margin lies concealed beneath the lateral portions of the pronotum (N_1) while its posterior, or dorso-caudal, margin, is demarked by the pleural suture extending from the wing base to the coxal process. While the mesepisternum is not definitely demarked from the mesosternum, it is divided into an anterior and posterior part by the *prepectal carina* (pcte). This is a strong, transverse carina originating on the median line of the sternum, which curves posteriorly away from the coxa, and then curves dorso-cephalad on the mesepisternum. Viereck (1916) used the presence or absence of this carina as a primary character for the separation of the various Ichneumonoid families in his Hymenoptera of Connecticut key, but this view is not accepted today by most taxonomists.

The *mesepimeron* (epm_2) is the narrow band lying dorso-caudad of the mesepisternum and separated from it by the pleural suture.

The *mesosternum*, as already mentioned, is fused with the mesepisternum to form a single sterno-pleural plate and there is no line of demarkation between the two areas.

Along the median line of the sternum, starting at the prepectal carina, there is a row of pit-like depressions which outwardly mark the line of attachment of the apophyses of the mesothoracic endoskeleton. The pleurosternal plate is modified posteriorly to form a *coxal process* projecting into the mesothoracic coxal cavity from its antero-median margin, while the *pleural coxal process*, formed at the end of the pleural ridge, projects into the coxal cavity from the postero-lateral margin thus forming the two points of articulation for the mesothoracic leg.

Mesad of the coxal cavities lies a triangular sclerite known as the *furcasternum* which is poorly demarked by carinae from the rest of the mesosternum (eusternum of the mesothorax). This is deeply invaginated along the median line and bears the internal structure called the *furca*.

METATHORAX

The tergum of the metathorax (Fig. 9) is composed of four sclerites which are called the prescutum, the scutum, the scutellum, and the postscutellum (all designated in figure 9 as N_3).

The *prescutum* is the depressed area directly behind the meso-scutellum and attached beneath it to the mesopostscutellum. It merges into the large, convex plate composed of the fused *metascutum* and *metascutellum*. This plate has usually been called the "postscutellum" or "metanotum." Crampton (1931), however, has shown that in the closely allied genus *Megarhyssa* the large dorsal plate lying directly posterior to the prescutum is the *metascutellum* while the narrow saddle-like band extending over the tergum between the metascutellum and the propodeum is the *metapostscutellum*.

The *metapostscutellum* curves cephalad as a narrow band forming the posterior margin of the hind wing base and at the lower margin of the wing base fuses with another narrow sclerite.

This last plate, which lies between the wing base and the metathoracic spiracle (sp_3), Crampton (1931) has shown to be composed of the fused *anepisternum* and *anepimeron* of the metathorax (aes_3 and aem_3). Below the spiracle the band widens out into a broad, slightly convex plate, usually called the "metapleura," but actually composed of the *katepisternum* and *katepimeron* of the metathorax (kes_3 and kem_3).

The lateral longitudinal carina extending cephalad from the metathoracic coxal cavity to a point just posterior to the mesothoracic coxal cavity seems to mark the line of division between the metapleural and metasternal regions. On the metasternum the line of attachment of the sternal apophyses is clearly demarked.

THE WINGS

The system of wing venation proposed by Ross (1936) has been used in this paper in preference to the artificial Cresson system usually used by taxonomists, or the Comstock-Needham system which is often figured in the older text-books. The system proposed by Bradley (1931) is somewhat similar to that of Ross (1936), but the latter seems to have worked out the origin of the main veins, particularly in the posterior portion of the wing, more carefully and on sounder grounds—*i.e.*, axillary sclerites instead of axillary furrows—and, for this reason, the Ross (1936) interpretation is used in this paper. The discussion of the wings follows the interpretation which Dr. Ross outlined to me in a

letter dated December 22, 1936, while the drawings of the wings are exact copies of a figure which he labelled at the same time.

FORE-WINGS

Costa (C) (Fig. 12) forms the thickened anterior, or front, margin of the wing. It arises just distad of the basicostal plate and extends along the anterior margin of the wing to the pterostigma, from which it is separated by a distinct break, the costal hinge.

Subcosta (Sc), present in the wings of primitive sawflies, has frequently been considered as fused into a "principal vein" with radius and media, but Bradley (1931) writes, "It is both simpler and more probably truthful to consider that it has atrophied entirely . . . therefore the marginal vein should be labelled C." Many writers have shown that Sc_1 becomes atrophied at an early stage in the phylogeny of the Hymenoptera, either in the Cimbicidæ or in the Siricidæ, while in the primitive *Macroxyela* type Sc_2 becomes separated from R_1 and extends along the anterior margin of the wing forming with R_1 the cell Sc_2 and R_1 . This cell has been retained in the intermediate forms becoming gradually thickened and growing by fusion, so that in *Arotes* the cell labeled Sc_2 and R_1 is actually the pterostigma, or "stigma." The break in the chitinization just before the pterostigma is called the *costal hinge*. It marks not only the termination of costa and the point at which Sc_2 attains the costal margin of the wing, but also indicates the point at which the radial sector turns inward.

Radius (R) is the second longitudinal vein. It forms the posterior margin of the very narrow costal cell, a cell so narrow that in most family keys to the Hymenoptera it is regarded as absent or "lost through coalescence," in contradistinction to the much wider costal cell of Aulacidæ and Gasteruptionidæ. Basally radius (R) (which is united with costa before the latter articulates with the basicostal plate) articulates with the second axillary sclerite. R forks but once, giving off an anterior branch R_1 (which marks the posterior margin of the stigma and continues beyond the stigma along the anterior margin of the wing, and a posterior branch, the radial sector (Rs), which fuses with the

first abscissa of Media just basad of the costal hinge. In all the Chalcidogastra the first abscissa of Rs + M (indicated in the figure by the dotted line) cuts across the cell $R_5 + 1st\ M$ and touches the first medio-cubital cross-vein (1 m-cu); but this first abscissa of Rs - M has been lost in all Ichneumonidæ and only a spur, called the *ramellus*, remains to prove the former existence of such a vein, as in *Cryptus* and *Exetastes*. In *Arotes* this spur is very tiny. Rs + M now extends antero-distad for a short distance and then divides into Rs and M, with Rs forking at almost a right angle just beyond 2 m-cu and then continuing in a gentle arc to the apex of the wing where it joins R_1 to form cell R_1 .

The cross-vein arising from the middle of the stigma, and connecting it with the radial sector, is the second radial cross-vein 2r.

The *areolet*, present in the wings of most Ichneumonidæ, is formed with the first abscissa of radius by the second radio-medial cross-vein.

Media (M), fused basally with cubitus, forms the third longitudinal vein. At its origin, media forms part of the compound vein complex just distad of the basicostal plate (bp), and is more definitely associated with the median plate (m). Just distad of the pteralia, media and cubitus separate from radius and proceed postero-distad along the basal third of the wing. Here media and cubitus fork, cubitus continuing to the anal angle, while media turns abruptly toward the stigma and joins the radial sector (Rs) a short distance from the costal hinge. (Note that according to the Ross interpretation, media never actually attains the base of the stigma, or the costal margin, although it does come very close.) As previously explained, Rs + M cuts across the cell R_5 and 1st M in the primitive Hymenoptera, but this abscissa of Rs + M has atrophied leaving only the tiny stump to mark its former location. From here Rs + M proceeds antero-apicad dividing abruptly into the radial sector (Rs), which eventually attains the apex of the wing, and M which extends in a gentle arc to the outer margin of the wing.

The first and second medio-cubital cross-veins connect the medial and cubital fields, 1 m-cu marking the terminus of the first abscissa of Rs + M and 2 m-cu marking the terminus of the second abscissa of Rs + M.

Cubitus (Cu), as explained previously, is associated with the base of radius and media, so that actually none of the four principal veins, namely costa, radius, media, and cubitus, arise independently. Cubitus apparently articulates with the anterior-distal corner of the median plate (m), and after proceeding for the basal third of the wing as a fused vein with M, divide into M and cu. Ross, following Tillyard's hypothesis of the loss of Cu₂ in the fossil *Permorphidia* and *Martynovia*, and the resultant carry-over in modern Holometabola, believes that Cu₂ has been lost in Hymenoptera and that the apical division of Cu should be called merely a division of Cu₁, with an anterior branch Cu_{1a} and a posterior branch Cu_{1b}.

The first cubito-anal cross-vein (1 cu-a) lies between cubitus and the first anal vein and connects the cubital and anal fields. The position of 1 cu-a with reference to the first abscissa of M is of considerable taxonomic importance, *i.e.*, whether 1 cu-a (called the nervulus by taxonomists) is opposite M (interstitial), proximal to it (antefurcal), or distal to it (postfurcal).

Anal Veins. The homologies of the anal veins are indeed a difficult problem. According to Ross (1936), there were originally four anal veins in the *Macroxyela* type, all articulating with the third axillary sclerite. In the lower Hymenoptera—*Macroxyela* as figured by Ross (1936) and *Itycorsia* (a pamphilid) as figured by Snodgrass (1910)—the bases of these anal veins are all distinct and separate. In the higher sawflies, however, a fusion of the bases of these anal veins begins to develop, associated with the dropping out of the second anal vein. In the Ichneumonidæ, as shown by *Megarhyssa* and *Arotes*, this fused base of the anal veins becomes very large and triangular in shape as a result of the fusion of the anals and only the first anal remains distinct. Both Snodgrass (1910) and Ross (in a personal letter) have shown that in Ichneumonidæ this is the *first anal vein* (1A). The second anal vein has dropped out in the sawflies (Ross, 1936) while the third anal vein has been identified as the tiny stub in the basal membrane arising from the middle of the fused base of the anals. The fourth anal vein is present only in the members of the Xyelidæ, and even in them is represented by only a tiny stump in the basal membrane.

The *first anal vein* (1A) is the fourth longitudinal vein and follows almost a straight course parallel to the inner margin of the wing, ending some distance before the anal angle of the wing.

The anal fold, or furrow, lying anterior to the first anal vein is indicated in the figure by a dotted line. It is clearly demarked by a line of dark setæ, which contracts strongly with the hyaline membrane at the base of the wings. As it extends to the anal angle of the wing, this anal fold breaks the chitinization of the veins 1 cu-a and Cu_{1b}, and the resulting membranous areas in these veins are called *bullæ*. There are three other bullæ in the fore-wing, one in the middle of the second abscissa of Rs + M, and the two others about equidistant from each other on the second medio-cubital vein (2 m-cu).

HIND WINGS

Although at first glance the venation of the hind wing (Fig. 13) appears to be radically different from that of the fore-wing, yet a closer examination shows that the scheme of modification has been essentially similar in both wings.

Costa (C) is the slightly thickened, anterior margin of the wing, extending at most only along the basal third of the wing.

Subcosta (Sc) is completely fused with radius.

Radius (R) divides into R₁ (which bends toward the anterior margin of the wing, and attains it, at the apical third) and Rs, which attains the outer margin of the wing just below the apex of the wing.

The *radio-medial cross-vein* (r-m) connects the radial sector (Rs) with the medial field (M).

The *hamuli*, a row of a dozen tiny hooks which fit into a pocket in the fore wings and hold the two wings together in flight, are borne on the basal part of R₁.

Media (M) separates from radius near its base, fuses with Cu₁ for a considerable distance, then separates from it and proceeds to the margin of the wing. It is connected to Rs by r-m, but the medio-cubital cross-veins are lacking.

Cubitus (Cu) is represented only by Cu₁, which does not divide into Cu_{1a} and Cu_{1b}, as in the fore wing, but continues to the margin of the wing simply as Cu₁. It is fused to Media to about

the middle of the wing and then separates sharply at a right angle, until it touches the cubito-anal cross-vein (cu-a), at which point it again becomes a longitudinal vein which parallels M to the outer margin of the wing.

Cu₁ and cu-a make up the very important structure known to taxonomists as the *nervellus*. In using this important structure for the separation of genera and species, taxonomists have three alternatives: it may be "broken above the middle," *i.e.*, first abscissa of Cu₁ shorter than cu-a; it may be "broken at about the middle," *i.e.*, first abscissa of Cu₁ about equal to cu-a; or it may be "broken below the middle," *i.e.*, first abscissa of Cu₁ longer than cu-a.

In *Arotes* taxonomists describe the *nervellus* as "broken at about the middle, and reclivous." This last term was first defined by Cushman and Rohwer (1920) with two other alternatives, as follows:

"A *perpendicular nervellus* is one in which the anterior end is opposite the posterior end, that is, one in which a line drawn touching both the anterior and posterior ends is at right angles to the longitudinal axis of the submediallan cell (Cell R₅). Other authors have called this a continuous or interstitial *nervellus*.

"An *inclivous nervellus* is one in which the anterior end is nearer the base of the wing than is the posterior end. This has been spoken of as a postfurcal *nervellus*.

"A *reclivous nervellus* is one in which the posterior end is nearer the base of the wing than is the anterior end. This has heretofore been spoken of as a postfurcal *nervellus*."

The *anal furrow* is indicated in the figure by a dotted line. Behind it lies a distinct longitudinal vein arising from the third axillary (3 Ax). This is the *first anal vein* (1 A).

Behind this first anal vein, extending into the first anal cell is a tiny spur of the *third anal vein* (3A).

PTERALIA OF THE FORE-WING

Each wing is attached to the thorax by a membranous basal area containing several tiny sclerites which Snodgrass (1935) has called the *pteralia*. These include in Hymenoptera an anterior *basicoatal plate* (which Snodgrass calls the *humeral plate*), a

group of four *axillary sclerites*, and a single *median plate* (which would seem to be the outer median plate, labeled m' by Snodgrass (1935, p. 219)).

In the fore wing (Fig. 11) the *basicostal plate* (bp) lies between the anterior notal process and the base of costa. It is a large plate resembling a second tegula somewhat and has a deep suture crossing it diagonally so that there appear to be two basicostal plates.

The *first axillary sclerite* (1 ax) is a peculiar twisted sclerite which articulates on its inner margin with the thorax and on its outer margin with the axillary sclerites and the base of the principal veins. Its inner margin articulates with the anterior notal process and with the tergal margin. On its outer margin, its anterior process forms a fulcral point for the basicostal plate and the second axillary, and on its under side it apparently also forms a fulcral point for a portion of the enlarged base of costa, radius, media, and cubitus.

The *second axillary sclerite* (2 ax) is hinged obliquely to the outer margin of the first axillary. Anteriorly it articulates with the base of radius and media (and through these with costa and cubitus) and with the median plate. Posteriorly, the second axillary articulates with the median projection of the third axillary.

The *third axillary sclerite* (3 ax) lies in the posterior part of the articular membrane just before the *axillary cord*. Anteriorly it articulates with the enlarged, triangular base of the first and third anal veins, mesally with the posterior end of the second axillary, and posteriorly with the fourth axillary.

The *fourth axillary sclerite* (4 ax) is a small sclerite lying between the third axillary and the posterior notal process.

The *median plate* (m) is probably the distal median plate labelled m' by Snodgrass (1935, p. 219). It is a triangular plate lying in the median area of the articular membrane. By its basal corner it articulates with the second axillary; but its anterior-distal corner, with the base of Cu; and by its posterior-distal corner, with the large, triangular base of the first and third anal veins.

PTERALIA OF THE HIND WING

The pteralia of the hind wings (Fig. 10) are similar to those

of the fore-wings. There is apparently no tegula in the hind wing and the base of the wing continues simply the articular membrane.

The *basicostal plate* (bp) articulates by its apex with the combined bases of costa, radius, media, and cubitus.

The *first axillary sclerite* (1 ax) is a V-shaped sclerite which articulates with the basicostal plate by its anterior process and with the second axillary by its posterior arm.

The *second axillary sclerite* (2 ax) in addition to its articulation with the first axillary, articulates by its anterior corner with the fused base of radius and media.

The *third axillary sclerite* (3 ax) articulates anteriorly with the base of the anal vein, mesally with the second axillary and posteriorly with the posterior notal process. There is no fourth axillary in the hind wing, as shown by Salman (1928) and Snodgrass (1910). Posterior to the third axillary the membrane is thickened to form the *axillary cord*.

The *median plate* (m) articulates posteriorly with the fused base of media and cubitus, and more particularly with the latter, and anteriorly with the base of the first anal vein.

CELLS OF THE WINGS

The names of the various cells have been figured by Cresson (1887), Comstock (1930), Bradley (1931), and Ross (1936). A comparison of the various systems as they apply to *Arotes* is given below.

Cells of the Fore Wing

Cresson	Comstock- Needham	Bradley	Ross
Pterostigma	Pt	Sc ₂ + R ₁	Sc ₂
Marginal, or Radial	2nd R ₁ - R ₅	2nd R ₁ + R ₅	2nd R ₁
Cubito-discoidal	M ₄	1st M ₄ + 1st R ₁	1st R ₁ + 1st M
Median	M	M	R
Third Submarginal	R ₅	1st + 2nd + 3rd R ₅	R ₅
First Apical	2nd M ₂	2nd M ₄	Cu _{1a}
Second Apical	M ₁	2nd M ₂	3rd M
Second Discoidal	Cu ₁	Cu ₁	Cu _{1b}
Third Discoidal	1st M ₂	1st M ₂	2nd M
Submedian	Cu	Cu + 1st A	Cu ₁
Anal	A	2nd A	1 A

Cells of the Hind Wing

Costal	C	C	C
Median	M	M	R
Radial	$R_1 + R_2$	R_1	R_1
Cubital or submarginal	R_5	R_5	R_5
Submedian	$M_4 + 1st$	$M_2 + M_1$	$M + Cu + Cu_1$
First Discoidal	M_1	M_2	$1st\ Cu_1$
Second Discoidal	M_2	M_4	$2nd\ Cu_1$
Anal	$1st\ A$	$2nd\ A$	$1st\ A$

THE LEGS

The legs are rather long and slender in proportion to the size of the body. The front pair is the smallest while the hind pair is the longest and largest, the hind femora of the male reaching to, or almost to, the tip of the abdomen.

Each leg (Fig. 8) is made up of a rather large *coxa* (cx), a distinct two-segmented *trochanter* (tr), a rather short and almost cylindrical *femur* (fe), an elongate *tibia* (ti), a five-segmented *tarsus* (ta), and a *pretarsus* (ptar) bearing a pair of claws.

In the hind legs the coxæ are almost pear-shaped. On the large basal end, each coxa is deeply incised on its postero-laterad surface by a *basicoxal suture*. The narrow band of chitin thus demarked expands above this suture into a semi-globular *basicoxite* which fits into the metathoracic coxal cavity, so that the articulation strongly resembles a ball and socket joint. The coxo-trochanteral articulation is dicondylic, for the distal end of the coxa is emarginate on either side and into these emarginations fit peg-like projections of the trochanters, sometimes known as *trochanter-condyles* acting as pivotal points. Posteriorly a levator muscle is attached to the trochanter; anteriorly the depressor muscle is attached.

The *trochanter* (tr) is almost as long as the coxa but is more slender and almost cylindrical. As in all Ichneumonidæ, the *trochanters* are two-segmented. Cushman (1929) calls the apical segment the *trochantella*, which is a very appropriate term since in this genus and in most other Ichneumonidæ the second segment is the smaller of the two segments. Snodgrass (1935), by a study of the muscle attachments, has shown this two-segmented trochanter is formed not by a division of the trochanters (as in Odonata) but by a basal subdivision of the femur; and Crampton (1925) thinks it is preferable to call this segment the

basifemur "rather than by the terms which imply that it is a part of the trochanter." The two segments are joined to each other by an *articular membrane*.

The *femur* (fe) is a strong, robust segment attached by articular membrane to the trochanter along a trochantero-femoral hinge. It is perhaps the most important leg segment from a taxonomic viewpoint because the coloration of this segment offers primary characters for the separation of the eight species of *Arotes* occurring in North America. The femora-tibial articulation is similar to that between the coxa and trochanter. The pivotal points of the femur, sometimes known as the *tibiafers*, are found on the anterior-lateral portions of the apical margin. Basad of this articulation, the proximal end of the tibia is produced into a distinct head, called the *tibiacaput* (Crampton, 1923), which is received in a distal pocket of the femur or the "femur cup." This device allows the tibia to be inflexed close to the under side of the femur.

The *tibia* (ti) is the longest and slenderest segment of the leg. It is narrower at the base and gradually expands toward the tip where it is of about the same diameter as the trochanter. On the apical margin of the tibia are two immovable spines about as long as the third tarsal segment. The mid tibia is similar to the hind one, both bearing two immovable, apical spines usually known as *tibial spurs*. The fore tibia, however, is relatively broader at the apex and bears on its apex one movable spine which is modified to form a part of the *antennal cleaner*. This spine is drawn between it and the modified inner basal surface of the basitarsus. The apex of the tibia is hollowed out to form a *tibiatheca*, or cup of the tibia, which receives the head of the basitarsus; so that the tibio-tarsal joint is in the nature of a ball and socket joint.

The *tarsus* (ta) is composed of five segments, of which the basal one, known as the *basitarsus* (formerly *metatarsus*), is as long as the next three segments together. The tarsal segments each expand slightly from base to apex. They are clothed with a fine short pubescence, but I have seen no trace of tarsal pulvilli or *euplantulae*. The fourth tarsal segment (ta_4), which is the shortest segment of the tarsus, is half as long as the apical tarsal segment. The subsegments of the tarsus are freely movable on

one another by inflected connecting membranes, but apparently as Snodgrass (1935) states, "the tarsus never has intrinsic muscles."

The fifth tarsal segment, or *distitarsus*, bears the *pretarsus* which is composed of two lateral claws and a complex series of structures between them.

The dorsal surface of the distitarsus (Fig. 14) bears on its apical margin a triangular-shaped sclerite, the *unguifer* (uf) to which the claws, or *ungues* (un), are attached.

On the ventral surface of the distitarsus, and partially concealed by it, lies a median plate, the *unguitractor* (ut). On its base it bears an *apodeme* (ap) to which is attached the depressor muscles of the pretarsus, often called the *retractor of the claws*.

The claws, or *ungues* (um), which are attached by flexor membrane to the unguifer and unguitractor, are large and curved. Each claw is noticeably cleft at the apex and typically bears two or three long spines on its base just laterad of the flexor membrane. The *planta* (pl) is a rather broad sclerite attached distally to the unguitractor plate. It is rather easily seen because of the three or four setæ it bears.

The *orbicula* (or), which is apparently attached to the unguifer, lies above the planta on the dorsal surface, and the girdle-like *camera* lies between the two.

The *camera* (cm) is a heavily sclerotized band which by its contractions and expansions changes the *arolium* (ar) from a small, membranous pad into a large, bilobed structure.

THE ABDOMEN

The *propodeum* (Fig. 3), long, erroneously, called the "metanotum" by taxonomists, is morphologically the tergite of the first abdominal segment. It is derived entirely from the tergum, the pleural and sternal plates having become atrophied as explained by Crampton (1931). Its hind margin broadens out into a semicircular band forming the dorsal half of the aperture through which the petiole of the abdomen projects and articulates with the thoracic region.

The *propodeal spiracles* are situated on the anterior lateral margin of the propodeum. These are long, oval, or slit-like spiracles, as contrasted with the short oval, or circular spiracles

of *Coleocentrus*, the other genus in the Acoenitini. The spiracles are about twice their own length from the base of the propodeum, and are connected with the base by carinae.

Various systems of naming the areas of the propodeum have been proposed from time to time. The systems introduced by Davis (1897) and by Morley (1903) seem to be most used by modern taxonomists, and for this reason are used in this paper.

1. Basal, or first median area (basareola)
2. Superior, or second median area (areola)
3. Apical, petiolar, or third median area (petiolarea)
4. External, or first lateral area
5. Area dentipara, external median, or second lateral area
6. Internal, middle apical, or third lateral area
7. Spiracular, or first pleural area
8. Lateral, middle pleural, or second pleural area

Snodgrass (1935) divides the abdomen proper into three groups: The *pregenital*, or visceral segments which, in *Arotes*, comprise the second to seventh segments; the *genital segments*, composed of the eighth and ninth segments in the female, and the ninth in the male; and the *postgenital segments*.

The abdomen in both sexes is slightly petiolate at the base. In the *male* (Fig. 17), the abdomen is more or less cylindrical throughout, expanding but slightly from base to apex, and is only slightly compressed apically. The abdomen of the *female* (Fig. 15) is cylindrical at the base, but expands medially, and becomes compressed from side to side on its apical third, in a manner suggestive of the Ophioninae. The most remarkable feature of the female abdomen (and the structure by which the female Acoenitini may be at once separated from all other Ichneumonidae) is the very large vomeriform hypopygium which is heavily sclerotized and acute at the apex.

The abdomen consists of nine distinct segments, exclusive of the propodeum, which is the true first tergite, and it is possible that the membranous area around the anus may well represent the eleventh tergite, in which case the abdomen proper is composed of ten segments.

The connection between the abdomen proper and the propodeum is made by the insertion of the basal end of the petiole, or true second abdominal segment, into the aperture formed by

the propodeum and the metasternum. The petiole apparently articulates with the propodeal part of this aperture by lateral projections of the base of the petiole. On the base of the petiole lies a median, dorsal ligament, called the *funicle*, which is attached anteriorly to the endoskeleton of the metathorax by muscles, and acts as a levator of the abdomen.

The *petiole*, or second abdominal segment (2t), according to Crampton (1931) is composed entirely of the second tergite which has extended ventrally and fused in the anterior region, crowding the second sternite (2s) backward in the process. The petiole is about three times as long as it is wide at the apex, and expands from base to apex. The oval spiracles lie in the middle of the petiole.

FEMALE ABDOMEN

In the female (Fig. 15), the tergite is bent at its basal third, and is produced into a small protuberance somewhat similar to the large basal protuberance in the petiole of such Mutillidæ as *Dasymutilla*. The *second pleurite* is a narrow, longitudinal band of membrane originating beneath the spiracle, and extending caudad to the third pleurite. It is demarked by a fold from the membranous *second sternite*.

The third to fifth abdominal segments are similar in general form and structure, each consisting of a tergite, sternite, and a pair of sclerites of uncertain affinities, which in this paper are called the *pleurites*. These three segments increase noticeably in size and sclerotization as they extend caudad. The tergites grow successively shorter, wider, and more convex; the pleurites become more strongly sclerotized; and the sternites show larger sclerotized areas in the sternal membrane.

In the sixth segment, the *tergite* (6t) fuses with the pleurite. The spiracle of the sixth segment, however, is just as far from the latero-pleural line as are the spiracles of the three preceding segments (which fact may indicate either that the pleurites are of recent origin, or more probably that the fusion of the sixth tergite with the pleurite has taken place quite recently), whereas the spiracles of the seventh, and eighth segments are quite near the latero-pleural line. The sixth sternite is almost completely sclerotized.

In the seventh abdominal segment, the tergite is similar to that of the sixth. The seventh segment is the largest segment of the abdomen, and combines the two features by which the females of this tribe are easily told from all others: the abdomen begins being compressed from side to side with the seventh tergite, and the *seventh sternite* (7s) is enormously elongated, very heavily sclerotized, and acute at the apex, producing what taxonomists call "the large, vomeriform hypopygium characteristic of the tribe Acoenitini." It is about one-third as long as the whole abdomen, or about as long as the three preceding segments together. This plate is concave, so that the ventral portions of the genitalia fit into it, and are concealed and protected by it. For this reason, it is often called the *subgenital plate* or *hypopygium*.

FEMALE GENITALIA

The genital segments of the female (Fig. 16) are composed of the eighth and ninth tergites and their appendages, for in *Arotes*, as in all Hymenoptera, there are no pleural or sternal plates on these segments in the females. The *eighth tergite* (8t) is slightly smaller than the seventh and its spiracle lies on the anterior edge of a distinct fovea. The *ninth tergite* (9t) is an elongate plate forming the fulcral point for both the ovipositor and the valves of the ovipositor. It has no spiracle.

The basal part of the *ovipositor* consists of the *first* and *second valvifers* (1 vf and 2 vf), which lie beneath the ventral margin of the ninth tergite. The *first valvifer* articulates by its dorsal angle with the ninth tergite, and by its posterior, ventral angle with the second valvifer. Anteriorly, the first valvifer has the form of a very thin, transparent plate, which is continuous with the ramus of the first valvulæ.

The second valvifer (2 vf) is a narrow, elongate plate, which lies half hidden beneath the ninth tergite. Anteriorly, it widens into a large, rounded process articulating with the first valvifer so that there is actually no articulation with the ninth tergite as in most typical insects; posteriorly, it broadens very slightly and becomes modified to form the long, slender *third valvulæ* (3v). It is continuous with the ramus of the second valvulæ along its extreme anterior margin, and its antero-dorsal margin

is produced into a long, pointed apodeme for the attachment of muscles.

The shaft of the ovipositor is elongate and compressed with an acute apex. The *ovipositor* itself is composed of the *first* and *second valvulae* (1 v and 2 v) which form respectively the ventral and dorsal parts of the ovipositor. The apical portion of the ovipositor is usually enclosed between the concave *third valvulae* (3v) which are often called the *valves* or *sheaths of the ovipositor*.

POSTGENITAL REGION

This is a membranous, apical area surrounding the anus. At the base there are weakly sclerotized dorsal and ventral sclerites which may represent the *tenth tergite* and *sternite* (10t and 10s) (Figs. 15, 16, 17). The *cerci* (ce) are borne in the membranous area between them and the *anus* at the extreme apex.

MALE GENITALIA

In *Arotes* the copulatory ossicles are located on the ventral side of the genitalia, and studies of the more primitive *Macroxyela* and certain Cephid genera would indicate that this is the more primitive, *orthandrous* condition, and that the torsion of the parts that occurs in some sawflies in the family Tenthredinidæ is a secondary development characteristic of the Tenthredinid complex called the Strophandria by Crampton (1919) and by Ross (1937).

The *basal ring* (br) (Figs. 18, 19) is a narrow, basal band enclosing the rest of the genitalia. According to Snodgrass (1935, p. 605), "it is said to differentiate as a circular fold of the wall of the genital chamber."

The *genital claspers*, or *parameres*, were first homologized with the parameres of Coleoptera by Wheeler in 1910, and his views on the subject have been accepted by Pruthi (1924), Balfour-Brown (1932), Snodgrass (1935), and Crampton (1936). The *parameres* (pr) arise on the ventral side of the basal band or ring and expand laterally into wide basal plates, which narrow again on the dorsal side meeting along a dorso-median caudal groove. Apically the parameres are lengthened into blunt, tooth-like projections which serve somewhat similar functions as the distal

segments of the parameres in lower saw-flies. These tooth-like projections, however, are probably not homologous with the distal segments of the parameres (which Crampton, 1919, called the *cochlearia* in the lower saw-flies) since these distal segments seem to drop out in the phylogeny of the Hymenoptera at about the Cephid level.

The *copulatory ossicles* are composed of a large basal portion known as the *volsella* (vol) and a smaller, slightly cylindrical apical segment called the *sagitta* (sag), which is connected to the volsella by membrane and is the true copulatory ossicle. They arise mesally on the parameres and project posteriorly, one lying on either side of the *ædeagus*. It should be emphasized especially, however, that in *Arotes* and also in *Coleocentrus*, which two genera comprise in America the tribe Acoenitini of Cushman and Rohwer, there is no *distivolsella*. Therefore, the inner forceps structure is lacking, although it is present in all the other Ichneumonidæ known to the present writer. The absence of the *distivolsella* in these two genera would seem, therefore, to be a character of tribal value in separating the Acoenitini from the other tribes of Ichneumonidæ, and it is possible that this character may be correlated with the huge development of the plow-shaped, or vomeriform, hypopygium in the female.

The central structure of the male genitalia is the *ædeagus*, which is composed of a pair of *penis valves* (ae). At the base of the *ædeagus*, on the dorsal side are a pair of *parapenes* (pap) which help to strengthen the pallic structure.

POSTGENITAL SEGMENTS

The postgenital segments (Fig. 17) are membranous but do include small sclerotized areas which would seem to be the tenth and eleventh tergites (10t and 11t) and the corresponding sternite. Snodgrass (1935) and other writers would call the small cercus-like appendages of the postgenital segments *socii* and would homologize them with similar structures in Trichoptera and Lepidoptera, but it is more reasonable to compare these appendages with those of male Mecoptera (since the genitalia of Hymenoptera are closest to those of Mecoptera) and to call them

true cerci as Crampton (1936) has done. The *anus* is situated at the very apex of the abdomen in both sexes.

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LIST OF ABBREVIATIONS

ae	—aedeagus	o	—ocellus
aem	—anepimeron	oc	—occiput
aes	—anepisternum	or	—orbicula
af	—antefrons	osc	—ocular sclerite
ap	—apodeme		
ar	—arolium	p	—pleurite
as	—antennal sclerite	pa	—parietals
at	—anterior tentorial pits	paf	—parafrontals
ax	—axillary sclerite	pap	—parapenes
		pc	—postocciput
bp	—basalar plate	pcs	—postoccipital suture
br	—basal ring		
C	—Costa	pete	—prepectal carina
cd	—cardo	pdc	—pedicel
ce	—cercus	pf	—postfrons
cl	—clypeus	pg	—postgena
cm	—camera	pgl	—paraglossa
Cu	—Cubitus	pl	—planta
Cx	—coxa	plst	—pleurostoma
		ppet	—prepectus
		pr	—paramere

epm	—epimeron	prmt	—prementum
eps	—episternum	pse	—prescutum
		pscl	—postscutellum
fe	—femur	ptar	—pretarsus
fl	—flagellum		
		R	—Radius
ga	—galea	Rs	—radial sector
ge	—gena		
gl	—glossa	s	—sternite
		sag	—sagitta
hp	—hypostoma	Sc	—Subcosta
hpe	—hypostomal carina	sc	—scutum
		sel	—scutellum
kem	—katepimeron	sep	—scape
kes	—katepisternum	smt	—submentum
		sos	—subocular suture
la	—lacinia	sp	—spiracle
laplp	—labial palpus	st	—stipes
lb	—labium		
le	—lacinia	t	—tergite
lm	—labrum	ta	—tarsus
		ti	—tibia
M	—Media	tr	—trochanter
m	—median plate		
m-cu	—medio-cubital cross-vein	uf	—unguifer
md	—mandible	un	—ungues
mxplp	—maxillary palpus	ut	—unguitractor
n	—notum	v	—valvula
		vf	—valvifer
		vol	—volsella

PLATE V

- Figure 1. Dorsal view of the head.
 Figure 2. Ventral view of the head.
 Figure 3. Dorsal view of the propodeum.
 Figure 4. Antenna.
 Figure 5. Labium.
 Figure 6. Maxilla.
 Figure 7. Mandible.
 Figure 8. Fore Leg.

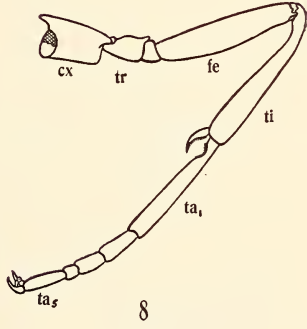
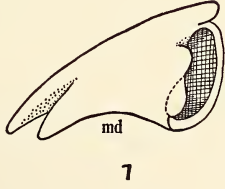
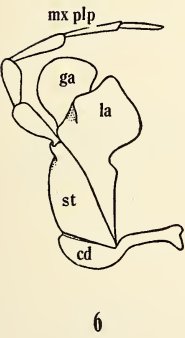
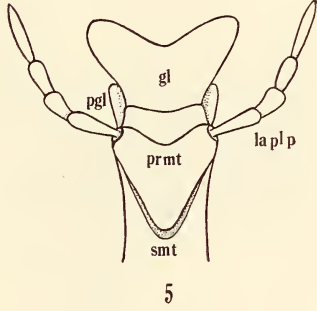
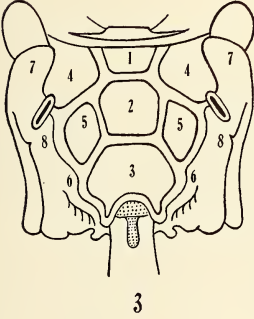
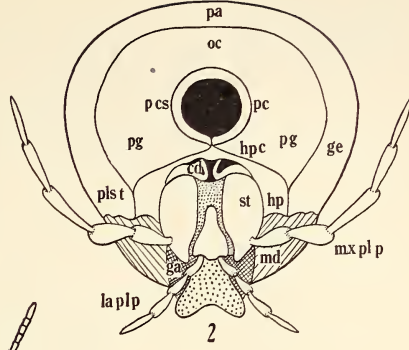
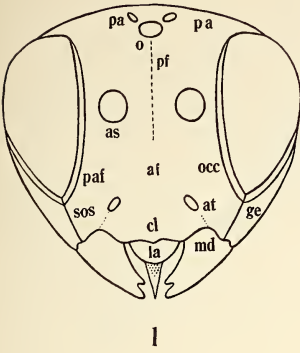


PLATE VI

- Figure 9. Lateral view of the pro-, meso-, and metathoraces.
Figure 10. Pteralia of the hind wing.
Figure 11. Pteralia of the fore wing.
Figure 12. Fore wing.
Figure 13. Hind wing.
Figure 14. Pretarsus of the hind leg.

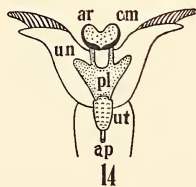
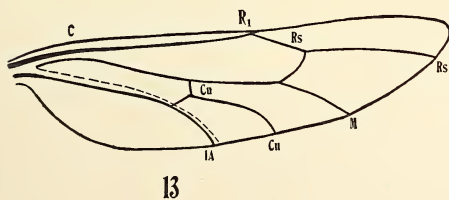
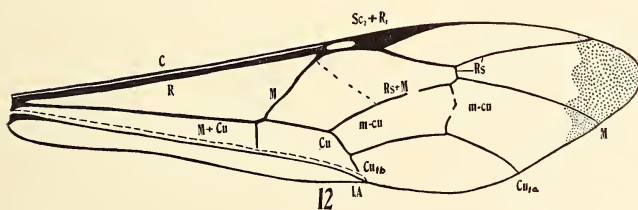
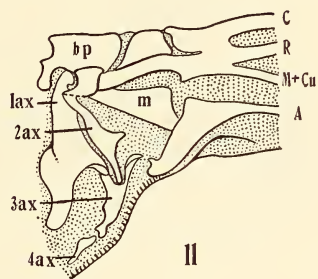
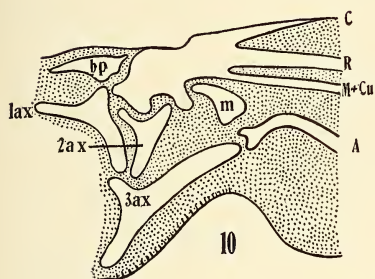
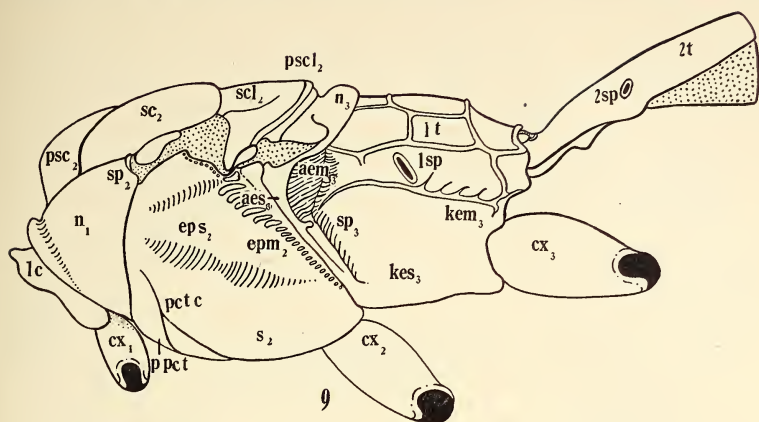
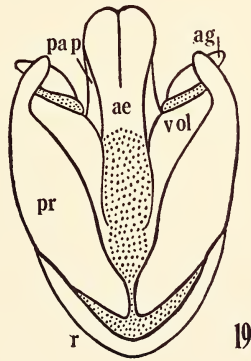
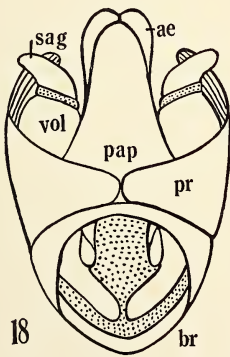
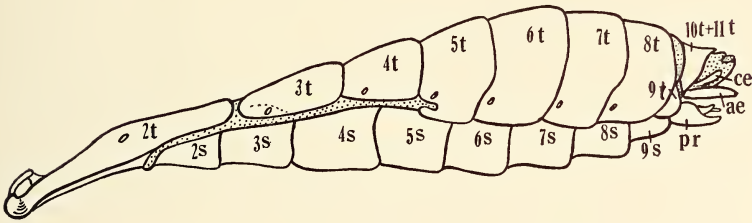
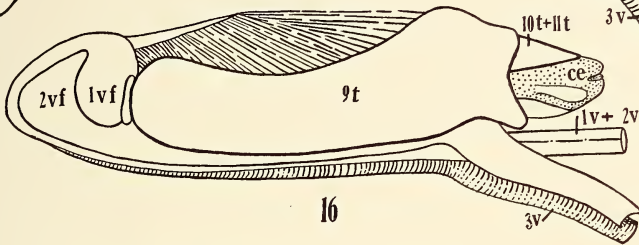
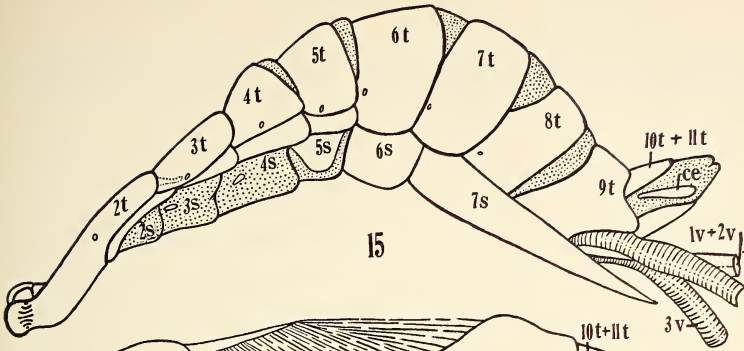


PLATE VII

- Figure 15. Lateral view of the female abdomen (ovipositor and sheaths
cuts off at tip of the abdomen).
Figure 16. Lateral view of the female genitalia.
Figure 17. Lateral view of the male abdomen.
Figure 18. Dorsal view of the male genitalia.
Figure 19. Ventral view of the male genitalia.



MONEY LOSSES DUE TO DESTRUCTIVE INSECTS

BY HARRY B. WEISS

It is customary, from time to time, for entomologists to call attention, in text books, special articles, newspapers, etc., to the enormous money losses due to destructive insects. These figures sometimes reach dizzy heights and carry the conviction that cold type seems to have for many readers. Without meaning to lessen the importance of destructive insects in their ability to create real crop losses of considerable magnitude, we would like, in this little article, to cast a few doubts upon the accuracy of the method in use at present whereby these losses are converted into dollars.

In arriving at the percentage of loss by insects, it is customary to obtain estimates indicating to what extent a particular insect has reduced the normal production of a crop to the production actually harvested. Having arrived at a figure indicating a loss in bushels, the value of this lost portion is obtained by basing it on the prevailing average farm price of the crop actually harvested, disregarding the reduction in value which usually follows the marketing of a larger crop. A few authors of papers on the subject of crop losses due to insects admit this error in their figures, but hold to them because of the absence of a better method and because they believe that the enhanced value given to the destroyed portion is offset by other losses chargeable to insects, such as the cost of control, which they have not included.

A quite recent publication cites the potato crop of the United States for 1936 as having been damaged to the extent of 15 per cent by insects. The total actual production of potatoes for that year was estimated at approximately 330,000,000 bushels. Because the supply was below the average that year the farm price went up and was about \$1.13 per bushel. Now, if the total production for that year had been 388,000,000 bushels, *i.e.*, the actual production plus 58,000,000 bushels, the estimated loss due to insects, the farm price would, in all probability, have gone down to around 60 cents per bushel, as it was in 1935 or 1937 or 1938, when production stood in proximity to 388,000,000 bushels. The

farm value in 1936 reached a figure of about \$370,000,000. If there had been no insect injury and if the production had been 388,000,000 bushels, the farm value at the lower price per bushel, provided the production could have been absorbed by the market, would have been about \$233,000,000, which is \$137,000,000 less than the farm value of the crop that was reduced by insects and actually produced.

To mention another example, apple production in the United States was supposed to have suffered a loss of 20 per cent in 1936 due to insects. Production for 1936 was estimated as 117,506,000 bushels, or 80 per cent of what the production should have been had there been no insect injury. The farm price for 1936 is quoted as \$1.05 per bushel. If the insect damage had been eliminated, the total production would have reached 146,883,000 bushels. Taking into account the purchasing power of the population since 1933, if 146,883,000 bushels had been thrown on the market, the price, in all likelihood, would not have gone higher than 75 cents per bushel, and even this is a generous allowance. The estimated farm value of the apple crop in 1936 was about \$123,381,000. With insect injury eliminated, resulting in a crop of 146,883,000 bushels, the total value at 75 cents per bushel would have been \$110,162,000, or more than \$13,000,000 in favor of the *status quo*. Of course having a crop of 146,883,000 bushels, more labor would be required to harvest, grade, pack and deliver it, provided the bottom did not drop out of the apple market completely. With the complete elimination of insect damage, a state of affairs not likely to happen, there would be some violently painful and long adjustments in the economics of the apple industry. A smaller number of trees would suffice, less labor would be employed and there would be changes all along the line. We have no desire to forecast what would happen to the farm and retail prices, or to the growers, etc., but if insect damage to crops were eliminated or greatly curtailed beyond the present amount, during the adjustment period surpluses would arise to plague us. But of course these could be handed over to some "Agricultural Surplus Commission" to worry about and would be of no concern to entomologists. If the large surpluses could be sold to countries where there were shortages, this would solve the problem, but in

the case of perishable crops, the surpluses might easily be calamitous. In the case of commodities that could be stored, the situation would be better, but even stored commodities in large amounts have a depressing effect upon market prices.

The percentages of damage, to various crops in the United States as a whole, by insects, as given in our text books, seem, for the most part, to run in multiples of 5, such as 5, 10, 15 and 20. Estimates seldom are less than 5 per cent or more than 20 per cent, and these are said to be conservative. To us, these estimates, for the most part, appear rather high for the country at large. They probably represent the opinions of a comparatively small number of technical men rather than the observations of numerous producers. The difficulty of obtaining reliable estimates from either source is fully appreciated. Numerous factors control production and the hazards of farming include not only insects, but plant diseases, defective seed, deficient moisture, excessive moisture, frost, hail, hot winds, storms, etc. Of the factors reducing normal production to the production actually harvested, adverse climate is the most important, and for the most part the effects cannot be avoided. Factors such as insects, plant diseases, poor seed, etc., may be overcome to a certain extent and the losses, due to them, reduced.

If the yield of a certain crop is 10 per cent less than the so-called normal yield, how is one going to apportion this loss to insects, plant diseases, deficient moisture, etc., etc., on the basis of our present knowledge, with any degree of accuracy? With stored products, of course, where only one factor is at work reducing the volume, the operation is not difficult. And there are other instances where insect damage is apparent and separable from injury by other causes and where it can be estimated or arrived at fairly accurately. In the case of a growing crop being injured by one species of insect, perhaps the loss in yield due to the insect can be estimated with some degree of accuracy, but even in this instance, there may be other factors tending to reduce the yield, including adverse climate, plant diseases, etc., and the assignment of loss due to each would be difficult. In the case of a growing crop being injured by several species of insects, the case becomes more difficult, in fact, the difficulties increase as the num-

ber of factors increases. Experimental work designed to isolate, and measure the effect of, single adverse factors in reducing yields would be costly, difficult and perhaps inconclusive. Even if we obtained, by counts in sample areas of a field, some idea of the numerical abundance of different species of insects, there would still remain the difficulty of converting this information into terms of bushels lost due to specific, adverse agents.

The possibility of arriving at a solution seems almost out of the question. On the other hand it would appear to be possible to increase the accuracy of the estimates of the percentages of insect damage to crops, by increasing the number of estimators and by giving them some common, fundamental basis for their estimates and by educating them in the importance of weighing the different factors. We have no confidence in the flat estimates by single individuals covering widespread areas, even whole states, unless it can be shown that such estimates are based upon extensive field observations and counts, where it has been possible to make them, and a full appreciation of the various factors involved. In the case of some estimates we have no doubt that such care is exercised, but entomologists as a rule are not conservative in estimating insect damage, and are inclined to extend to a very large area the estimates that have been based on a very small and unrepresentative sample, and that may represent a special case.

In Mr. J. A. Hyslop's useful paper on "Losses Occasioned by Insects, Mites, and Ticks in the United States" (U.S.D.A. Bur. Ent. and Pl. Quar., Wash., D. C., July, 1938, mimeographed) there is a wide variation in the percentage losses, due to various insects, as gathered by him from different sources and this one would expect. They are, no doubt, as correct as existing facilities and interest in the subject permitted them to be. Many of them seem conservative, especially if one has no definite information with which to check them. Some were no doubt arrived at on the basis of surveys and counts. And they forcibly call attention to the seriousness of insect injury to crops. However, we do not believe that they are all as accurate as it is possible to make them.

When these losses are converted into dollars they total to a staggering sum which includes the enhanced value given to the

destroyed portions of the crops. It is the enhanced values that we believe should be written off in the interest of accuracy. As a matter of fact, the destroyed portions have no market or other value. They don't exist. If insect damage could be eliminated completely, the larger production during the readjustment period would result in a lower price. In trying to give a unit value to something that does not exist, and did not actually come into existence, we either have to give it the same unit value of the crop that does exist, which is not correct, or assume that the increased production due to the elimination of insects could actually be marketed at the lower price. As this is only an assumption and as increased production through elimination of insects, in many cases, would result in a farm value much less than if the reverse happened, *i.e.*, lower production due to insect damage, why is it necessary to attempt to convert bushel losses into dollars? Why not allow these losses in production, when they are arrived at as accurately as possible, to remain in bushels? It is too bad that our standards of value require so many things such as insect damage, college educations, etc., to be valued in terms of dollars.

From an economic viewpoint large farm surpluses at present would not be regarded as blessings. If our present surpluses, due to better methods of production, etc., the dislocation of foreign trade, industrial unemployment, etc., are still further augmented by the elimination of all insect damage, which is highly theoretical, our social and economic life would have to undergo severe readjustments. Before large surpluses can be sold to low income groups, a change in our methods of distribution will have to take place. Economic entomologists should not dream of the complete elimination of all losses due to insects, nor talk as if it would really be desirable for this to happen. They should be content to see their recommendations employed sufficiently to prevent insect damage from reaching the proportions of disaster, or in seeing that such damage is kept down to a reasonable level. Even though they are more ambitious than this, there are always enough lax producers, and insects, to keep production at a level more or less consistent with the economics of the times.

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No. 3

THE SARCOPHAGINÆ AND THEIR RELATIVES IN NEW YORK. II¹

BY HAROLD C. HALLOCK

LANCASTER, PA.

Sarcophaga Meigen

1826. Meigen, Syst. Besch. Zwei. Ins., vol. 5, p. 14.

1916. Aldrich, *Sarcophaga* and Allies, p. 5.

Aldrich (1916) gave a full account of the history of the genus, *Sarcophaga*, and the distinguishing characters which will not be repeated here. The hypopygial studies have given additional evidence that there can be some grouping of the species within the genus. These structures are more important as the final characters to be used in distinguishing some of the closely related species.

The New York species (*bisetosa*, *cimbicis*, and *latisterna*), which Parker (1914) placed in the genus *Boettcheria*, have several common genitalic characters. There is a small rounded projection on each side of the V of the fifth sternum a short distance before its point of union. The sperm pump sclerite of each of these three species is thickened along the margin of its larger end and they are similar in size and shape. The posterior claspers of the three species are more or less enlarged on the front side near the base.

¹ This article is a continuation of "The Sarcophaginæ and their relatives in New York. I." JOUR. N. Y. ENT. SOC. vol. 48, pp. 127-153, 1940.

Contribution from the Entomological Laboratory, Cornell University, Ithaca, N. Y.

SEP 21 1940

The New York species (*laakei*, *latisetosa*, *l'herminieri*, *pusiola*, *stimulans*, and *sueta*) of the *Ravinia* group have many similar hypopygial structures. When the anal forceps are viewed from the back it is noticeable that each is united near its base, becomes widely separated and then generally tend to be closer together at the apex. There is a remarkable resemblance in the shape of the ædeagus of these five species as will be seen by examining the illustrations. Three species, *l'herminieri*, *sueta*, and *pusiola* have a similar arrangement of short, stout bristles along each inner margin of the V of the fifth sternite. The species, *laakei*, *latisetosa*, and *stimulans*, do not have this striking bristle arrangement but are similar to each other as they have an enlargement on the inner margin of the V of the fifth sternite.

It is evident that *barbata* and *securifera* are closely related. Although the anal forceps can be distinguished they have a striking resemblance in their shape. Each species has a broad accessory plate, a row of bristles along the posterior margin of the anterior claspers, two bristles on the front margin near the apex of the posterior claspers, considerable similarity in the shape of the fifth sternites and the arrangement of the bristles along the inner margins of the V of their fifth sternites.

There is some similarity in the ædeagus and anal forceps of *alcedo* and *uncata* but the shape of the fifth sternites would not lead one to expect very close relationship between these two species. Aldrich (1916) compared both of these species to *excisa*. There are several species in this group that have many characters in common but they are not as closely related to each other as the species within the *Ravinia* or *Boettcheria* groups.

It is true that there are distinct groups within the genus *Sarcophaga*. Yet it does not seem wise to attempt to express this relationship by creating separate genera for these related species. In almost all the cases it would be nearly impossible to find generic characters which would place the females in the proper genus. The writer desires in the near future to study the hypopygial structures of the female *Sarcophaga* which may help to show relationships within the group. It would also be wise to supplement these characters by comprehensive larval studies of the type conducted by Knippling (1936) and studies of the habits of the related species.

Although there is a very striking similarity in the appearance of the adult *Sarcophaga*, the habits of the immature stages show considerable variation. As Aldrich (1916) brought to our attention these flies are now in the interesting transition from the habit of devouring dead animal tissues to parasitism upon living tissue. The larvæ of the *Ravinia* group develop in excrement. There are many *Sarcophaga* which have the habit of developing in dead flesh as illustrated by *Sarcophaga bullata*. The aquatic *Sarcophaga*, which develop in pitcher plants, feed largely upon dead insects but they will attack and kill living insects which occur in the water found in the pitcher plant. There are many true parasitic forms in the *Sarcophaga* and these may be illustrated by *S. atlanis*, which attacks grasshoppers, *S. aldrichi*, which attacks chiefly the forest tent caterpillar, and *S. cimbicis*, which has a wide variety of hosts. Although *S. cimbicis* may develop as a true parasite the larvæ have also been reared on meat. The habits of the New York species will be discussed more fully under each individual species.

The keys given in the present paper include all Sarcophaginæ known to occur in New York state in order that the identification of the flies may be made simpler and confusion avoided. Characters other than those found on the genitalia have been used whenever possible in the first key to the males. A second key to the males, which is based entirely upon genitalia characters, has been given in order to aid the student in the study of this group. The third species key deals with the female Sarcophaginæ of New York where known material has been available for study.

Genotype.—*Sarcophaga carnaria* (Linn.)

KEY TO SEPARATE MALE SARCOPHAGINÆ

1. Three distinct postsutural dorsocentrals 2
 Four postsutural dorsocentrals, or else the anterior ones of the postsutural series indistinct, scarcely differentiated from hairs 31
2. Hind tibiæ with villosity, the hairs of which are at least longer than the diameter of the tibiæ 3
 Hind tibiæ without erect villosity (the appressed hairs at most not longer than the diameter of the tibiæ) 9
3. Hypopygium entirely black 4
 At least the second segment of the hypopygium red or yellow 5

4. Abdomen pollinose, at most the hinder parts of the segments shining black; middle femur with a patch of yellow hairs on the apical third of front sides.....*Sarcophaga sinuata* Meig.
Abdomen with three rows of shining black spots on the second, third, and fourth segments; middle femur without yellow hairs
Wohlfahrtia vigil Walker
5. Anterior acrostichals present 6
Anterior acrostichals absent 8
6. Prescutellar bristles present, the third abdominal segment with a complete row of marginal bristles.....*Sarcophaga sarraценiæ* Riley
Prescutellar bristles absent, the third abdominal segment with only median marginal bristles 7
7. Accessory plate long, slender, finger-like, only the distal end of the row of median bristles on the hind femur present
Sarcophaga latisterna Parker
Accessory plate not finger-like, a complete row of median bristles on hind femur.....*Sarcophaga cimbicis* Townsend
8. Third abdominal segment with a complete row of marginal bristles, fourth abdominal segment yellow apically.....*Sarcophaga sima* Aldrich
Third abdominal segment with only a median pair of marginal bristles, fourth abdominal segment entirely black
Sarcophaga bisetosa Parker
9. Hypopygium entirely black..... 10
At least second segment of the hypopygium red or yellow..... 17
10. The frontal bristles extending below the base of the antennæ 13
The frontal bristles not extending below the base of the antennæ..... 11
11. Arista short plumose 12
Arista long plumose; legs largely yellow; abdomen largely yellow in the light form and abdomen dark in the dark form
Opsodexia bicolor Coq.
12. Legs entirely black; palpi brownish and nearly as long as the proboscis
Oppiopsis sheldoni Coq.
Tibiæ yellow; palpi yellow and only about one-third the length of proboscis*Opelousia obscuria* Town.
13. Anterior acrostichals wanting 16
Anterior acrostichals present and well developed 14
14. Ground color of ventral portion of abdomen largely red, second and third abdominal segments with only median marginal bristles
Sarcophaga fletcheri Ald.
Ground color of ventral portion of abdomen black..... 15
15. Accessory plates nearly as long as anal forceps; the V lacking on the fifth ventral sternum*Laccoprosopa sarcophagina* Town.
Accessory plates short; fifth sternite has a well developed V
Sarcophaga nox Hall
16. Palpi yellow, forceps with strong protuberances on dorsal half, on which are striking tufts of long black hair.....*Sarcophaga hunteri* Hough

- Palpi black, forceps slender, protuberances and tufts of hair lacking
Sarcophaga atlantis Ald.
17. First, third and fifth longitudinal veins hairy, fourth abdominal segment and hypopygium yellowish red *Johnsoni borealis* Reinhard
 Only first and third longitudinal veins hairy 18
 Third longitudinal vein only hairy 19
18. Anterior acrostichals well developed, second abdominal segment with median marginal bristles *Metoposarcophaga importuna* Walker
 Anterior acrostichals not differentiated from the surrounding hairs, second abdominal segment without median marginal bristles
Sarcophaga rapax Walker
19. Palpi yellow 20
 Palpi black 22
20. First segment of hypopygium with a row of stout bristles near its base, fifth sternite entire 21
 First segment of hypopygium without row of bristles near base, the row of bristles at apex often indistinct, fifth sternite deeply cleft forming a distinct V *Sarcophaga hunteri* Hough
21. Arista plumose; parafacials and parafrontals light golden yellow pollinose *Sarcophaga ravinia* Parker
 Arista bare or slightly pubescent; parafacials and parafrontals gray pollinose *Erythrandra picipes* B. & B.
22. Arista long and thin, short-plumose; the second segment of the large hypopygium red and with long bristles *Hypopelta scrofa* Ald.
 Species not as described 23
23. Anterior acrostichals absent or scarcely differentiated from surrounding hairs *Sarcophaga parallela* Ald.
 Anterior acrostichals well developed 24
24. Epaulets yellow, frontal rows of bristles not divergent below
Sarcophaga pusiola V. d. W.
 Epaulets black, the frontal rows of bristles suddenly divergent in the last two or three bristles 25
25. The third abdominal segment with a pair of median marginal bristles, median marginal bristles absent on the second abdominal segment 26
 Species lacking the above combination of characters 29
26. Wings slightly smoky, hind calypters light brown with a white margin, parafacials and parafrontals yellow pollinose
Sarcophaga alcedo Ald.
 Species lacking the above combination of characters 27
27. Fourth abdominal segment yellow apically; accessory plate broad and deeply excised at apex *Sarcophaga excisa* Ald.
 Fourth abdominal segment black; accessory plate round at apex 28
28. Apex of ædeagus with a long tube-like portion which is incurved at end to form a loop that can be seen through *Sarcophaga reversa* Ald.
 Tip of ædeagus without loop, but with thin expanded margins which are whitish or transparent *Sarcophaga uncata* V. d. W.

29. Ruffle-like expansions lacking on ædeagus, the minute incurved copulatory tube concealed by the stout divergent prongs at the tip of the ædeagus.....*Sarcophaga aculeata* Ald.
 On the discal portion of the ædeagus appear lateral, thin expanded margins which are white or transparent and shaped similar to a ruffle 30
30. A pair of erect median marginal bristles on the second abdominal segment, the distal portion of the ædeagus distinctly notched to form two sharp points at the apex.....*Sarcophaga setigera* Ald.
 Median marginal bristles rarely present on second abdominal segment (when present small and widely separated); distal segment of ædeagus swollen and whitish at end with no sign of notch
Sarcophaga coloradensis Ald.
31. Hind tibiæ with villosity, the hairs of which are at least longer than the diameter of the tibiæ..... 32
 Hind tibiæ without erect villosity (the appressed hairs are at most not longer than the width of the tibiæ 45
32. Hypopygium entirely black..... 33
 At least the second segment of the hypopygium red..... 37
33. Middle tibiæ with long dense villosity; front approximately as wide as one eye.....*Sarcophaga johnsoni* Ald.
 Middle tibiæ without villosity; front much narrower than the width of the eye 34
34. Anal forceps broad, approximately the same width for three-fourths their length; anterior claspers deeply grooved on back
Sarcophaga aldrichi Parker
 Species lacking the above characters..... 35
35. Ædeagus globose with several long slender processes at apex
Sarcophaga misera var. *harpax* Pand.
 The long slender processes at apex of the ædeagus lacking..... 36
36. The ædeagus with a large hump on the back; second abdominal segment with median marginal bristles.....*Sarcophaga houghi* Ald.
 The ædeagus without conspicuous hump on the back; the second abdominal segment without median marginal bristles
Sarcophaga montanensis Hallock
37. First segment of hypopygium black on apical half..... 38
 Both segments of hypopygium yellow or reddish in color..... 41
38. The precutellar bristles absent; the forceps with a notch behind near base.....*Sarcophaga hæmorrhoidalis* Fall.
 Species lacking the above characters 39
39. A single row of black hairs back of eyes, abundant white beard which extends over the back of the head up to the row of black hairs behind eyes.....*Sarcophaga securifera* Vill.
 With more than one row of black hairs back of eyes and white beard less extensive 40

40. Forceps without emargination and hump behind; ædeagus with slender processes at tip; two rows of black cilia behind eyes; white hair on posterior portion of cheeks.....*Sarcophaga misera* var. *exuberans* Pand.
Forceps with an emargination behind followed by a hump, terminal portion of ædeagus much enlarged and no slender processes
Sarcophaga barbata Thompson
41. The middle tibiæ with long villosity, which begins about the middle..... 42
Middle tibiæ without long villosity..... 43
42. The length of villous hair on hind tibiæ approximately twice the diameter of the tibiæ; length of villous hair on middle tibiæ approximately equal to the diameter of tibiæ
Sarcophaga scoparia var. *nearctica* Parker
The length of villous hairs on hind tibiæ approximately three times the diameter of the tibiæ; length of villous hairs on middle tibiæ twice the diameter of tibiæ.....*Sarcophaga fulvipes* var. *triplasia* V. d. W.
43. Third abdominal segment without median marginal bristles
Sarcophaga cooleyi Aldrich
Third abdominal segment with median marginal bristles..... 44
44. Forceps not tapering to a point but with an apical tooth formed by an excision on the front edge; distal segment of ædeagus not unusually broad, with long slender processes at tip; three rows of black cilia behind eyes; hairs on cheeks black
Sarcophaga misera var. *sarracenioides* Ald.
Forceps tapering to a sharp point; distal segment of ædeagus broad and blunt.....*Sarcophaga bullata* Parker
45. First vein hairy..... 54
First vein bare..... 46
46. Epaulets yellow..... 47
Epaulets black..... 48
47. Fourth segment of abdomen and first segment of hypopygium widely yellowish red; parafrontals and parafacials yellow pollinose
Sarcophaga sueta V. d. W.
Fourth segment of abdomen and first segment of hypopygium black; parafrontals and parafacials gray pollinose
Sarcophaga l'herminieri Rob.-Des.
48. Palpi yellow, pale hairs of beard conspicuous in front of metacephalic suture.....*Sarcophaga flavipalpis* Ald.
Palpi entirely black..... 49
49. Scutellum with a pair of apical bristles between the large marginal bristles 50
The apical bristles on the scutellum lacking 52
50. Frontal bristles extending below the base of the antennæ and the last two or three bristles in the frontal rows divergent; parafrontals and parafacials gray pollinose..... 56
Frontal bristles not extending below the base of antennæ and not divergent; parafrontals and parafacials golden yellow pollinose..... 51

51. Fourth abdominal segment and the hypopygial segments covered with golden yellow pollinose hairs *Macronichia aurata* Coq.
Fourth abdominal segments and the hypopygial segments covered with only gray pollinose *Macronichia confundens* Town.
52. Front approximately as wide as one eye *Sarcophaga cistudinis* Ald.
Front much narrowed below the ocelli so that it is about half as wide as one eye 53
53. Anterior acrostichals present; fourth abdominal segment black apically; legs yellow *Sarcophaga ventricosa* V. d. W.
Anterior acrostichals absent; fourth abdominal segment yellow apically; legs black *Sarcophaga cingarus* Ald.
54. First segment of the hypopygium red and fourth abdominal segment partially red *Sarcophaga laakei* Hall
First segment of the hypopygium black and fourth abdominal segment black 55
55. Outer vertical bristles present *Sarcophaga latisetosa* Parker
Outer vertical bristles absent *Sarcophaga stimulans* Walker
56. Forceps with dense erect short hairs almost at tip *Sarcophaga utilis* Ald.
Short erect bristly hairs lacking near tip of forceps 57
57. Forceps parallel to the tip, cut bluntly at tip, and the two forceps curved beneath so as to give a spoon appearance when viewed beneath
Sarcophaga niagarana Parker
Forceps parallel more than three-fourths the length but tips widely separated so as to form a semi-circle when viewed from behind
Sarcophaga yorkii Parker

KEY TO SEPARATE MALE SARCOPHAGINÆ

BASED ON HYPOPYGIAL CHARACTERS

1. Fifth sternite cleft, so that two lobes extend caudad, generally forming a V 3
Fifth sternite entire with no sign of a V on its caudal margin 2
2. Both segments of hypopygium black *Wohlfahrtia vigil* Walker
Both segments of hypopygium red *Sarcophaga ravinia* Parker
3. First segment of hypopygium large, flat behind so that the abdomen appears truncate; pump sclerite unusually large as its diameter is twice the length of the ædeagus
Metoposarcophaga importuna Walker
First segment of hypopygium normal; pump sclerite small 4
4. Fifth sternum with a pair of median pad-like projections at the point where the gradual sloping V suddenly becomes nearly parallel sided on the caudal margin (*Bættcheria* group) 5
The V of the fifth sternum without pad-like projections 7
5. The tip of the ædeagus long and extending cephalad with a number of slender processes beneath; posterior claspers normally slender
Sarcophaga latisterna Parker
The tip of the ædeagus strongly curved back caudad; posterior claspers with a decided enlargement near their middle 6

6. Anal forceps short and wide, basal half or more with tufts of very striking long, black hair; anterior clasper with tooth of apex
Sarcophaga cimbicis Town.
 Anal forceps longer, curved at tip and without striking tufts of hair; anterior claspers curved at apex *Sarcophaga bisetosa* Parker
7. Apex of ædeagus with two black transverse arms which curve around forward and make an almost perfect ring and each arm is divided into two points at the apex
Sarcophaga scoparia var. *nearctica* Parker
 Ædeagus without the characteristic arms 8
8. Anal forceps cleft approximately two-thirds or more of the distance from the tip to the base 9
 Anal forceps cleft only a short distance or not more than half way from the tip to the base 22
9. Anal forceps nearly straight in profile with a notch behind near base of cleft; arising from the front side of the ædeagus a little before the tip are a pair of curved arms reaching forward which together with the flat and enlarged tip suggest the figure of a small dog sitting up in the attitude of begging
Sarcophaga hæmorrhoidalis Fall.
 Species lacking the above characters 10
10. Distal segment of the ædeagus in the form of a long tube which is incurved at the end and forming a loop that can be seen through in profile beyond the lateral processes *Sarcophaga reversa* Ald.
 Distal portion of ædeagus without loop that can be seen through 11
11. Forceps when viewed from back show a deep depression on the caudal side about the middle 12
 Forceps without the depression 16
12. The yellow forceps rather square at the tip, and the base of the forceps enlarged into a prominent lobe which bears a striking tuft of straight black hairs twice as long as the forceps
Sarcophaga hunteri Hough
 Anal forceps without lobe and tuft of black hairs 13
13. Fifth sternite large, the V is cut out somewhat in the form of a semi-circle, the lower portion of the V margined with strong bristles; distal segment of ædeagus large with a keel-like hind margin which extends in a curve over the tip into a pronounced free hook turned forward *Sarcophaga flavipalpis* Ald.
 Species lacking the above characters 14
14. Inner margins of anal forceps parallel for half of distance to the points, then suddenly turned outward so that the points of forceps are widely separated; the margins of the V of the fifth sternite parallel over half the distance to the point and then suddenly divergent so that points are widely separated, a group of stout bristles on inner margins about one-third distance from points
Sarcophaga alcedo Ald.
 Species lacking the above characters 15

15. Fifth sternite with a bristly projection on each of the inner margins of the V at about its middle; ædeagus without ruffle

Sarcophaga atlanis Ald.

- Fifth sternite without projection on the inner margins of the V; ædeagus with a lateral white fringe or ruffle on its apical half

Sarcophaga uncata V. d. W.

16. Anal forceps widely separated from each other at tip and at base attached to each other only for a short distance; bristles confined largely to outer margins of forceps; the usual V-shaped cleft of the fifth sternite is a linear fissure in this species and on each side of the fissure behind is a small black hood-like point

Sarcophaga fletcheri Ald.

Species without these characters (*Ravinia* group) 17

17. Anterior claspers with a row of bristles extending the entire length of caudal margin 18

Anterior claspers without bristles on caudal margin 19

18. Aedeagus when viewed from behind decidedly narrowed before the apex; anal forceps less widely separated at tip than at one-fourth of distance toward base *Sarcophaga l'herminieri* R.-D.

Ædeagus when viewed from behind not narrowed; anal forceps gradually divergent toward apex *Sarcophaga sueta* V. d. W.

19. Ædeagus ending in two rounded enlargements separated by a median notch, on front side well before the apex are two pairs of processes projecting forward *Sarcophaga pusiola* V. d. W.

The ædeagus without rounded enlargements 20

20. Anterior clasper terminating in point and nearly as long as ædeagus; posterior clasper slender and smooth on front side; fifth sternite broadly excised *Sarcophaga stimulans* Walker

Anterior clasper much shorter than ædeagus; posterior clasper with two small humps on front margin near tip; the fifth sternite less broadly excised 21

21. Anterior clasper hallowed out or dished on front margin at tip so that it has the appearance of being toothed *Sarcophaga latisetosa* Parker

Anterior clasper ending in a point without any dished appearance on front margin *Sarcophaga laakei* Hall

22. The V of fifth sternite narrowed almost to a linear fissure; forceps when viewed from side are turned back near the apex to appear somewhat like the barb of a hook *Sarcophaga ventricosa* V. d. W.

The V of fifth sternite normal; anal forceps without barbed-like appearance 23

23. Anal forceps black, broad and with shining area on lower half when viewed on the caudal side; anterior claspers large and deeply grooved on front side almost to the apex

Sarcophaga aldrichi Parker

Anal forceps without broad shining area; anterior claspers not deeply grooved 24

24. Hypopygium very small; a single very long bristle on anterior margin of posterior claspers; a few long curved bristles at tip of V of fifth sternite *Sarcophaga rapax* Walker
Hypopygium normal size; posterior claspers without long bristles; fifth sternite without long curved bristles at apex of V 25
25. Ædeagus with a large hump on the back side near the apex; the diverging lobes of the V of the fifth sternite covered with short, stout, black bristles *Sarcophaga houghi* Aldrich
Ædeagus without hump 26
26. Arms of the V of the fifth sternite very widely divergent, the portion of sternite around the union of V covered with strong bristles; distal segment of ædeagus very broad and blunt 27
Species with different characters 28
27. Accessory plate covered with short bristles only; tip of ædeagus with a process curving forward which is cut off bluntly on front apex and ædeagus only slightly narrowed at junction of its two segments
Sarcophaga cooleyi Parker
Accessory plate with long bristles at its apex; the process at tip of ædeagus ends in a sharp point and the ædeagus is very much narrowed at junction of the two segments..... *Sarcophaga bullata* Parker
28. Arms of V of fifth sternite long, slender and sparsely covered with slender hairs, at the union of the V arms are two circular pads which are densely covered with bristles; anal forceps have abundant short, stiff erect hairs on the front and back sides just beyond their lower angle but the extreme tips of forceps are bare
Sarcophaga johnsoni Aldrich
Circular pads lacking on fifth sternite and some true strong bristles on fifth sternite; characteristic groups of short, stiff erect hairs lacking on anal forceps 29
29. Tips of ædeagus with five characteristic slender processes (*misera* group) 33
Tips of ædeagus without the long slender processes 30
30. The entire hypopygium black 31
At least the second segment of hypopygium red 32
31. Posterior clasper with a long bristle near base; apex of ædeagus with a raised light colored piece extending around its tip
Sarcophaga nox Hall
Posterior clasper without long bristle near base; raised light colored piece lacking on apex of ædeagus *Sarcophaga sinuata* Meig.
32. Anal forceps with a hump on the caudal side just before the apex; and the front side concave to form a hooked tip; the apex of the ædeagus with two long slender processes which are distinctly widened at the apices *Sarcophaga securifera* Vill.
Anal forceps without hump; processes when present on the ædeagus lack the enlarged apices 35

33. Both hypopygial segments black; processes arising from apex of ædeagus slender and the ones curved around to the front are toothed at the apex *Sarcophaga misera* var. *harpax* Pand.
At least the second segment of hypopygium wholly red; processes at apex of ædeagus not toothed at tip 34
34. First segment of hypopygium generally brownish black; distal processes of ædeagus long and very slender
Sarcophaga misera var. *exuberans* Pand.
Both segments of hypopygium red; distal processes of the ædeagus shorter and thicker *Sarcophaga misera* var. *sarracenioides* Ald.
35. Anal forceps in back view contiguous to the tip 41
Anal forceps not contiguous to the tip 36
36. Posterior claspers much enlarged and attached to ninth sternite for at least half their length, a row of long bristles on caudal margin of posterior claspers; anterior claspers greatly curved, toothed, and with a long bristle near the base *Hypopelta scrofa* Aldrich
Anterior and posterior claspers normal 37
37. Anterior clasper slender, widened apically, the tip excised to form a distinct claw; arms of fifth sternite black
Sarcophaga sarracenie Riley
38. Apex of ædeagus ending caudad in a keel which turns sharply forward in the form of a hook; anal forceps excised in front to form an apical tooth 40
Apical segment of ædeagus very wide and without a distinct keel at apex; anal forceps not excised in front to form an apical tooth 39
39. Apex of anal forceps with a row of short bristles on front and back sides just back of tip; tip of anal forceps from side view resembles a head of a bird *Sarcophaga utilis* Aldrich
Apex of anal forceps without bristles and not resembling a head of a bird 42
40. Anterior clasper dished on the anterior surface; the anterior process of the apex of the ædeagus, when viewed from the back, appears like a broad scoop with its center curved back and the caudal keel comes up around it *Sarcophaga sima* Aldrich
Anterior clasper not dished but with a notch at the apex, the front margin of apex of ædeagus somewhat rectangular in shape
Sarcophaga parallela Aldrich
41. Forceps with a lateral process near tip *Sarcophaga cingarus* Aldrich
Forceps without lateral process near tip
Sarcophaga niagarana Parker
42. Forceps cleft nearly half their length; ædeagus large and apical circle lacking *Sarcophaga barbata* Thompson
Tips of anal forceps separated only a very short distance; ædeagus moderate size and its apical end shaped to form a semicircle when viewed toward the tip *Sarcophaga yorkii* Parker

KEY TO SEPARATE FEMALE SARCOPHAGINÆ

1. Three distinct postsutural dorsocentrals 2
 Four postsutural dorsocentrals, or else the anterior ones of the postsutural series indistinct, hardly differentiated from hairs 19
2. Genital segments mostly black 3
 Genital segments red or reddish yellow 5
3. Arista bare; epaulets yellowish brown
Laccoprosopa sarcophagina Town.
 Arista long plumose; epaulets black 4
4. Anterior acrostichals absent, mid-femur with patch of yellow hairs on apical third of front side *Sarcophaga sinuata* Meig.
 Anterior acrostichals present; mid-femur without yellow hairs; palpi yellow *Sarcophaga hunteri* Hough
5. Anterior acrostichals absent, not differentiated from hairs 6
 Anterior acrostichals present 10
6. First vein hairy, scutellum with apical bristles, small species
Sarcophaga rapax Walker
 First vein bare, larger species 7
7. Second abdominal segment with median marginal bristles, ground color of ventral portion of abdomen largely red
Sarcophaga fletcheri Aldrich
 Second abdominal segment without median marginal bristles, ground color of abdomen largely black 8
8. Prescutellar bristles absent; arista long and thin, short plumose; palpi black *Hypopelta scrofa* Aldrich
 Species lacking the above grouping of characters 9
9. Palpi black; arista long plumose *Sarcophaga bisetosa* Parker
 Palpi yellow; plumosity of arista only median length
Sarcophaga ravinia Parker
10. Second abdominal segment with erect median marginal bristles 11
 Second abdominal segment without erect median marginal bristles ... 13
11. Epaulets yellow, abundant whitish beard *Sarcophaga atlanis* Aldrich
 Epaulets black, beard black 12
12. Median marginal bristles on second abdominal segment erect and close together, fourth abdominal segment entirely black, larvipositor sharp and bent forward *Sarcophaga setigera* Aldrich
 Median marginal bristles when present on second abdominal segment not erect and considerable distance apart, fourth abdominal segment yellow apically, larvipositor rounded and not bent forward
Sarcophaga excisa Aldrich
13. Three maginal pairs of bristles on scutellum 14
 Two long marginal pairs of bristles on scutellum 16
14. Sides of fourth abdominal segment nearly covering fourth sternite, apical edges of fourth segment rapidly separating, forming a V, and exposing the red fifth sternite
Metoposarcophaga importuna Walker

- Fourth sternite widely exposed as the fourth tergites are widely separated ventrally 15
15. Anterior cross-vein infuscated *Sarcophaga cimbicis* Town.
Anterior cross-vein not infuscated *Sarcophaga latisterna* Parker
16. Epaulets yellow, mid tibiae with two bristles on outer front side
Sarcophaga pusiola V. d. W.
Epaulets black 17
17. Wings slightly smoky, hind calypters light brown with a white margin
Sarcophaga alcedo Aldrich
Wings hyaline, calypters white 18
18. Fourth abdominal segment yellow apically, genital orifice rounded and surface of dorsal half without bristles
Sarcophaga excisa Aldrich
Fourth abdominal segment entirely black, yellow larvipositor pointed and the surface of dorsal portion covered with bristles
Sarcophaga reversa Aldrich
19. Impression of the bucca, near the vibrissal angle, large, conspicuously submerged below the surface level of surrounding sclerite; vibrissae placed at least the length of second antennal joint above the oral margin; ovipositor drawn out into a long slender point 20
Species lacking the above combination of characters 21
20. Fourth abdominal segment and the hypopygial segments covered with golden yellow pollinose hairs *Macronichia aurata* Coq.
Fourth abdominal segment and the hypopygial segments covered with gray pollinose hairs *Macronichia confundens* Town.
21. Genital segments mostly black 22
Genital segments entirely red or reddish yellow 24
22. Palpi black *Sarcophaga aldrichi* Parker
Palpi yellow 23
23. Third abdominal segment with only a pair of median marginal bristles
Sarcophaga johnsoni Aldrich
Third abdominal segment with complete row of marginal bristles; abdomen with three rows of shining black spots on second, third, and fourth segments. Eastern species *Wohlfahrtia vigil* Walker
24. Anterior acrostichals present 25
Anterior acrostichals absent 29
25. Epaulets black, dark yellow palpi which are rather long and broad
Sarcophaga flavipalpis Aldrich
Epaulets largely yellow; palpi black 26
26. First vein hairy 27
First vein bare 28
27. Middle femur with two bristles on outer front side
Sarcophaga stimulans Walker
Middle femur with more than two bristles on outer front side
Sarcophaga latisetosa Parker

28. Parafrontals, parafacials and front half of bucca with strong ochraceous pollinose; thorax and abdomen with yellowish pollen
Sarcophaga sueta V. d. W.
 Yellowish pollen replaced by gray pollinose, with reflections that are rather brownish than yellow *Sarcophaga l'herminieri* Rob.-Des.
29. Prescutellar bristles present 30
 Prescutellar bristles absent *Sarcophaga hæmorrhoidalis* Fall.
30. Fifth vein with strong setæ along vein on the upper side of the wing
Johnsoni borealis Reinhard
 Fifth vein without setæ 31
31. At least one-fourth of beard white 32
 Beard containing no white hairs 37
32. Whitish beard of metacephalon extends well forward of the suture, blending with the black hairs 33
 Whitish beard not extending beyond the suture and blending with the black hairs 35
33. Single row of black bristles behind eyes, bucca with abundant white beard which also extends over back of head up to row of black hairs, dorsal marginal bristles lacking on third abdominal segment
Sarcophaga securifera Vill.
 Not with above combination of characters 34
34. A single row of bristles in cheek groove extending nearly the entire height of parafacials *Sarcophaga barbata* Thompson
 Bristles on lateral sides of parafacials irregularly arranged and not in a single row *Sarcophaga bullata* Parker
35. Middle tibiæ with three bristles on the outer front, a group of parafacial macrochætæ present, three distinct rows of black hairs behind eyes, genital orifice triangular in shape and fringed with bristles above *Sarcophaga misera* var. *sarracenioides* Ald.
 Characters not in the above combination 36
36. Fourth abdominal segment yellow apically, parafacial bristles not arranged in a distinct row *Sarcophaga cistudinis* Aldrich
 Fourth abdominal segment entirely black, a row of strong bristles extending nearly the entire length of parafacials
Sarcophaga scoparia var. *nearctica* Parker
37. The hind and mid-femur yellowish red *Sarcophaga ventricosa* V. d. W.
 The hind and mid-femur dark colored (black)
Sarcophaga cingarus Aldrich

MISERA GROUP

The species placed in this group have been recognized only as varieties of *misera*, the first species described in the group. Parker (1919) and Hardy (1927) gave the history of this group and so it will not be repeated here. Although there is an unusually close resemblance of the male hypopygium in all the species

in the *misera* group the males may be separated from each other. On the other hand it is very difficult to separate the females from other *Sarcophaga* which do not belong in the *misera* group. Additional studies may show that these species should be raised from the rank of varieties to species and place them in a sub-genus. The writer would not go further as it does not seem wise to erect a genus based upon the characters of only one sex. A clear understanding of the group can be secured only by extensive rearings and a careful study of all stages.

Sarcophaga misera var. *exuberans* Pand.

1896. Pandellé, Rev. Ent., vol. 15, p. 186.
1912. Böttcher (*S. tuberosa* var. *exuberans* P.), Deutsch. Ent. Zeitschr., p. 735.
1916. Aldrich, *Sarcophaga* and Allies, p. 232.
1919. Parker (*S. dux* var. *exuberans* P.), Bull. Brooklyn Ent. Soc., vol. 14, p. 41.
1927. Hardy (*S. misera* var. *exuberans* P.), Proc. Linn. Soc. N. S. Wales, vol. 52, p. 452.

There are several very closely related forms that have been placed in the *misera* group by the different students of *Sarcophaga* which can be separated only by close study. Their separation depends largely upon genitalia characters which have been given in the keys. It should be kept in mind that *exuberans* has two rows of black cilia behind the eyes and white vestiture on the posterior portion of the cheeks.

Records.—Ithaca. June to August. Figure 98.

Jack (1935) reports this species to have been reared from dead insects in South Rhodesia, Africa. Callot (1935) reared the species from adults of *Stauroderus bicolor* Ch.

Type.—In the Pandellé collection in Paris.

Sarcophaga misera var. *harpax* Pand.

1896. Pandellé, Rev. Ent., vol. 15, p. 189.
1912. Böttcher (*S. tuberosa* var. *harpax* P.), Deutsch. Ent. Zeitschr., p. 735.
1916. Aldrich (*S. tuberosa* var. *harpax* P.), *Sarcophaga* and Allies, p. 171.

1919. Parker (*S. dux* var. *harpax* P.), Bull. Brooklyn Ent. Soc., vol. 14, p. 41.

1927. Hardy (*S. misera* var. *harpax* P.), Proc. Linn. Soc. N. S. Wales, vol. 52, p. 452.

1930. Aldrich, Proc. U. S. N. M., vol. 78, p. 27.

Only a single specimen of *Sarcophaga misera* var. *harpax* P. has been taken in New York State. This form is easily distinguished from all other varieties of *misera* that occur in America. The genitalia segments are entirely black. The processes at the apex of the ædeagus, which curve anteriorly, are distinctly toothed at their tips. The cheeks are clothed with black hairs.

Length.—8 to 12 mm.

Record.—Pelham Park, New York City. Figure 99.

Aldrich (1916) states that the fly has been reared from Gypsy moth caterpillars. Senior-White (1927) records the rearing of *harpax* from decaying snails.

Type.—In the Pandellé collection in Paris.

Sarcophaga misera var. *sarracenioides* Ald.

1916. Aldrich (*S. tuberosa* var. *sarracenioides*), *Sarcophaga* and Allies, p. 227.

1919. Parker (*S. dux* var. *sarracenioides* A.), Bull. Brooklyn Ent. Soc., vol. 14, p. 41.

1927. Hardy (*S. misera* var. *sarracenioides* A.), Proc. Linn. Soc. N. S. Wales, vol. 52, p. 452.

This species, *sarracenioides*, is one of the most common *Sarcophaga* occurring in New York. There is a single row of strong black cilia and two other rows of weaker black cilia behind the eyes. The vestiture of the cheeks is black. •

Length.—8 to 13 mm.

Records.—Axtion; Ithaca; New York City; *L. I.*: Cold Spring Harbor; Babylon; Half-way Hollow Hills. May to September. Figures 100, 101 and 102.

A very wide range of rearings have been reported for this species. It is certain in many cases that living insects have been parasitized. Aldrich (1916) reported 45 adults from grasshoppers at widely distributed localities; 1 adult from the western cricket in British Columbia; 5 adults from *Heliopila unipuncta* in Oklahoma; 23 adults from *Lachnosterna* sp. in Kansas; 2

adults from *Eleodes tricolorata* in Oklahoma; 2 adults from *Allo-rhina nitida* in Virginia and 66 adults from carrion in Texas. Davis (1919) found the fly parasitizing *Phyllophaga* sp. in Illinois. Treherne and Buckell (1924) reported parasitism by this fly on grasshoppers in British Columbia. Knipling (1936) reared this species from meat. The writer in 1935 found that *sarracenioides* would larviposit on the inner surface of a funnel of a beetle trap above dying Asiatic garden beetles and that the first instar maggots would drop about six inches to reach the bodies of the beetles.

Holotype and allotype.—Male and female, No. 20551, U. S. N. M.

BOETTCHERIA GROUP

Parker (1914) described *Boettcheria* as a new genus and placed three species, *bisetosa*, *cimbicis* T. (*fernaldi* P.) and *latisterna*, in the genus. The females were excluded from consideration in Parker's (1914) paper. Aldrich (1916) stated that the species are closely allied but expressed the doubt, "if the fact is best expressed by raising them to generic rank." The writer, under the discussion of the genus *Sarcophaga*, has pointed out additional hypopygial characters which are common to the flies in this group. It is hoped that opportunity may be secured to conduct additional studies later with the immature forms and the adult female flies which may show that it is advisable to place these species in a separate genus.

Sarcophaga bisetosa Parker

1914. Parker, Proc. Boston Soc. Nat. Hist., vol. 35, p. 69.

1916. Aldrich, *Sarcophaga* and Allies, p. 81.

Parker (1914) separated this species from the closely related *cimbicis* mainly by the absence of anterior acrostichals and only two sternopleurals while *cimbicis* has three sternopleurals. The enlarged tip of the aedeagus, which turns back caudad, separates this species from all the closely related species.

Length.—8 to 12 mm.

Records.—Ithaca; Albany; White Lake; Trenton Falls; Yonkers; *L. I.*: Half-way Hollow Hills. May to September. Figures 103, 104 and 105.

Information is not available about the immature stages.

Type.—Mass. Agri. College.

Sarcophaga cimbicis Townsend

1892. Townsend, Can. Ent., vol. 24, p. 126.

1896. Van der Wulp (*S. setulosa*), Biol. Cent. Am., vol. 2, p. 276.

1914. Parker (*S. fernaldi*), Proc. Boston Soc. Nat. Hist., vol. 35, p. 72.

1916. Aldrich, *Sarcophaga* and Allies, p. 79.

1930. Aldrich, Proc. U. S. Nat. Mus., vol. 78, p. 32.

The characters given in the two male and female keys easily separate this species from the two very closely related species (*bisetosa* and *latisterna*). In most localities *cimbicis* is more plentiful than either *bisetosa* or *latisterna*.

Length.—5 to 10 mm.

Records.—Erie Co.; Ithaca; Albany; Carmel; W. Nyack; New York City; Tuxedo; Brewster; Poughkeepsie; Oneonta; Rome; Troy; S.I.: Watchogue; Ft. Wadsworth; L.I.: Babylon; Jericho; Riverhead; Heckscher State Park. May to October. Figures 106, 107 and 108.

Kelly (1914) recorded the species as a parasite of adult grasshoppers in Kansas. Aldrich (1916) recorded that the type species was reared at Brookings, S. Dak., from pupa of *Cimbex americana*. Hayes (1917) found the fly breeding in dead insects. Davis (1919) reared this species in Illinois from adult *Phyllophaga* sp. Sherman (1920) reared *cimbicis* from the green clover worm larva (*Plathypena scabra*). Breakey (1929, 1931) recorded the larva of the iris borer as a host of *cimbicis*. The writer (1929) found 40% of the adult beetles (*Xyloryctes satyrus*) had been parasitized by this fly at Jericho on Long Island. Experiments at that time tended to indicate that *cimbicis* would not larviposit upon dead insects. Knipling (1936) pressed larvæ from the female flies and reared them on meat. Decker (1931, 1932) in Iowa recorded the parasite from *Papaipema nebris* and *Epiblema otiosana*.

Type.—In University of Kansas.

Sarcophaga latisterna Parker

1914. Parker (*Boettcheria*), Proc. Boston Soc. Nat. Hist., vol. 35, p. 67.

1916. Aldrich, *Sarcophaga* and Allies, p. 77.

Two striking characters distinguish this species from the closely related forms found in New York. It has a long slender accessory plate and on the hind femur a group of striking long bristles which are present only on the distal end of the median row.

Length.—8 to 13 mm.

Records.—Grand Island; Ithaca; Karner; King Ferry; Rensselaer; *S.I.*: Arrochar; Wadsworth; New Dorp; New Brighton; Watchogue; Richmond; *L.I.*: Babylon; Half-way Hollow Hills. May to August. Figures 109, 110 and 111.

Aldrich (1916) and Chittenden (1926) listed the species as a parasite of the imported cabbage worm (*Pieris rapæ*). Phillips and King (1923) reared *latisterna* from the corn ear worm. Porter and Alden (1924) recorded a rearing from the larva of the canker worm. Breakey (1929) gave a record of rearing *latisterna* from the iris borer larva in Wisconsin. Knull (1932) reared the fly from the pupæ of *Ennomos subsignarius* in Pennsylvania. The writer (1929) recorded on October 1, 1926, adult *latisterna* flying thickly around the larvæ of *Anisota* sp. at Taunton Lakes, New Jersey. Although gravid female flies were abundant no parasitism was secured. Maggots were removed from gravid female flies and placed on dead insects. These maggots developed normally. Knipling (1936) also reared this species on meat after removing larvæ from the fly.

Type.—Male, in Mass. Agri. College.

RAVINIA GROUP

The genus *Ravinia* was erected by Desvoidy (1863) with *Sarcophaga haematodes* Meig. as genotype. Böttcher (1912, 1913) recognized the group only as a sub-genus. Parker (1914) returned *Ravinia* to generic rank and pointed out that, in addition to the frontal bristles diverging anteriorly, there was a striking resemblance in the male copulatory organs. Aldrich (1916) and Hall (1928) reduced the genus to sub-generic standing because as Aldrich stated, "the characters of the frontal row is less developed in the males," and, "there are many species outside the group which show it." Hall (1928) added the statement, "the course of the frontal bristles range from parallel in some species

to strongly divergent in others; all species possessing striking similar copulatory organs." No additional characters have been observed so the group is considered only as of sub-generic rank.

Sarcophaga laakei Hall

1931. Hall, Ann. Ent. Soc. Am., vol. 24, p. 181-182.

It is difficult to separate this species from the closely related form, *latisetosa*. The characters given in the key will separate the two species. This species occurs fairly common in the south but it has been taken only a few times on Long Island, New York, by Mr. F. S. Blanton.

Length.—6 to 7 mm.

Records.—*L.I.*: Babylon. June, August. Figure 112.

Knipling (1936) reared larvæ of *laakei* on meat.

Holotype.—No. 43264, U. S. N. M.

Sarcophaga latisetosa Parker

1914. Parker (*Ravinia*), Proc. Boston Soc. N. H., vol. 35, p. 63.

1916. Aldrich, *Sarcophaga* and Allies, p. 299.

1928. Hall, Ann. Ent. Soc. Am., vol. 21, p. 343.

The outer vertical bristles are present in this species but they are lacking in the closely related *stimulans* and the posterior clasper is much longer in *latisetosa* than in *stimulans*.

This species is very common in the northern part of the United States and Canada but it is taken in fewer numbers south.

Length.—6 to 7 mm.

Records.—Ithaca; McLean; Duck Lake; Herkimer; Tuxedo; Troy; Poughkeepsie; *L.I.*: Cold Spring Harbor; Babylon. June to September. Figures 113, 114 and 115.

Aldrich (1916) states that the larvæ of this species are excrement feeders. Professor G. W. Herrick reared twelve adults of this species at Ithaca from dog excrement in July 1912.

Holotype.—Male, in collection of Mass. Agri. College.

Sarcophaga l'herminieri R.D.

1830. Robineau-Desvoidy, Essai Sur les Myodaires, p. 339.

1837. Walker (*anxia*, *querula*, *avida*, *rediviva*, *aspera*, *rabida*, *acerba*, *comes*), Trans. Linn. Soc., vol. 17, p. 818-825.

1868. Thompson (*S. pallinervis*), Eugenies Resa, p. 535.
1914. Parker (*Ravinia communis*), Proc. Bost. Soc. N. H., vol. 35, p. 55.
1916. Aldrich (*S. communis*), *Sarcophaga* and Allies, p. 253.
1930. Aldrich, Proc. U. S. N. M., vol. 78, p. 13, 27, 28.

This scavenger species is the most common Scarophagid in New York State. It occurs in all parts of the state.

Length.—6 to 12 mm.

Records.—Tuxedo; Middleport; Rome; Trumbull Corners; Tear; Potsdam; Unionport; Buffalo; Ithaca; Mosholu; *S.I.*: New Brighton; Fort Wadsworth; *L.I.*: Flatbush; Sea Clift; Cold Spring Harbor; Gardiners Island; Wyandanch; Brooklyn. May to September. Figures 116, 117 and 118.

Parker (1914), Aldrich (1916) and Wilson (1932) have all recorded this species abundantly feeding and larvipositing on all kinds of mammal excrement. Knipling (1936) found that larvæ of this species would develop when placed upon either excrement or meat.

Type.—Museum of Natural History in Paris.

Sarcophaga pusiola V. d. W.

1896. Van der Wulp, Biol. Cent. Am. Dip., vol. 2, p. 278.
1914. Parker (*Ravinia peniculata*), Proc. Bost. Soc. N. H., vol. 35, p. 58.
1916. Aldrich (*S. peniculata*), *Sarcophaga* and Allies, p. 121.
1930. Aldrich, Proc. U. S. N. M., vol. 78, p. 33.

The superficial characters of this species are similar to *l'herminieri*. This species belongs to the three postsutural dorso-central group while *l'herminieri* has four postsutural dorsocentrals. The average size of *pusiola* is smaller than *l'herminieri*.

Length.—6 to 9 mm.

Records.—Redhook; Tuxedo; Tear; Upper Ausable; Olcott; Ithaca; *L.I.*: Cold Spring Harbor. June to September. Figures 119, 120 and 121.

Parker (1914) recorded rearing the larvæ of this species from dung. Knipling (1936) found that larvæ normally developed upon excrement but that they could develop upon meat.

Sarcophaga stimulans Walker

1848. Walker, List of Dip. Brit. Mus., p. 817.

1895. Van der Wulp (*S. vagabunda*), Biol. Cent. Am. Dip., vol. 2, p. 270.
1900. Coquillett (*S. quadrisetosa*), Ent. News, vol. 12, p. 17.
1914. Parker (*Ravinia quadrisetosa*), Proc. Bost. Soc. N. H., vol. 35, p. 60.
1916. Aldrich (*S. quadrisetosa*), Sarcophaga and Allies, pp. 296.
1917. Townsend (*Chætoravinia quadrisetosa*), Proc. Biol. Soc. Wash., vol. 30, p. 195.
1928. Hall (*S. quadrisetosa*), Ann. Ent. Soc. Am., vol. 21, p. 346.
1930. Aldrich, Proc. U. S. Nat. Mus., vol. 78, p. 15, 29.

Although this species occurs in New York it has never been taken as commonly as the closely related *latisetosa*. Hall (1928) reported *stimulans* more numerous south of the Ohio River than in the northern part of its range.

Length.—6 to 8 mm.

Records.—Yonkers; *S.I.*: Clove Valley; *L.I.*: Babylon. August. Figures 122, 123 and 124.

Aldrich (1916) and Greene (1926) reported that this fly is a very common excrement feeding species in its larvæ stage. Knippling (1936) reared this species from excrement but failed to secure development of larvæ upon meat.

Type.—In British Museum.

Sarcophaga sueta V. d. W.

1896. Van der Wulp, Biol. Cent. Am. Dip., vol. 2, p. 281.
1916. Aldrich (*S. communis* var. *ochracea*), *Sarcophaga* and Allies, p. 255.
1928. Hall (*S. ochracea*), Ann. Ent. Soc. Am., vol. 21, p. 340.
1930. Aldrich, Proc. U. S. N. M., vol. 78, p. 34.

For many years *sueta* was considered in America as a variety of *l'herminieri* but Greene (1926) pointed out distinct differences in the immature stages. Hall (1928) raised this form to the rank of species. This species occurs commonly from southern Ohio to the southern part of the United States. It has been taken on rare occasions on Long Island, New York.

Length.—6 to 12 mm.

Records.—*L.I.*: Babylon. August. Figures 125, 126 and 127.

Aldrich (1916), Lindquist (1936) and Knippling (1936) have pointed out that the larvæ of this species develop in excrement.

TYPICAL SARCOPHAGA GROUP

The remaining species of the genus *Sarcophaga* are placed in this group. Additional study may show that it is desirable to divide this residuary group into smaller groups.

Sarcophaga aculeata Aldrich

1916. Aldrich, *Sarcophaga* and Allies, p. 143.

Although this species has not been recorded in New York State it is so widely distributed in the United States and Canada that it can be expected to occur here. According to Aldrich (1916) this species has been reared from the adults of several species of grasshoppers.

Holotype and allotype.—Male and female, No. 20526, U. S. N. M.

Sarcophaga alcedo Aldrich

1916. Aldrich, *Sarcophaga* and Allies, p. 132.

This species is close to *S. excisa* but it can be separated by the distinct yellow cast on the parafrontals and parafacials, wings slightly smoky and hind calypters light brown with a white margin. The genitalia differences are illustrated in the figures.

Length.—8 to 9 mm.

Records.—Although this species is widely distributed in the United States it has only been recorded in New York at Babylon, L.I., where Mr. F. B. Blanton has taken 12 specimens. August. Figures 128, 129 and 130.

The hosts of *alcedo* are not known.

Holotype and allotype.—Male and female, No. 20517, U. S. N. M.

Sarcophaga aldrichi Parker

1916. Parker, Jr. Econ. Ent., vol. 9, p. 438.

1916. Aldrich, *Sarcophaga* and Allies, p. 167.

This species belongs to a small group of flies with four post-sutural dorsocentral bristles, hind tibiae villous in the males and the hypopygium entirely black. The males of this species may be separated from the closely related species in this group by the broad anal forceps with a large bare, shining area on their lower central portion and the deep groove on the large thick anterior

clasper. The female has black genital segments with an oval aperture which is surrounded by dense bristles.

Length.—8 to 10 mm.

Records.—Ithaca; Oneonta; Axton; Mt. Whiteface; *L.I.*: Babylon; Herscher State Park. May to the middle of July. Figures 131, 132 and 133.

Adults of this species occur commonly around infestations of the forest tent caterpillar (*Malacosoma disstria*). Cæsar (1916) reported in Ontario that 90% of the larvæ of the forest tent caterpillar were parasitized by this fly. Parker (1916) recorded a rearing from *Porthetria dispar*. It has also been reared according to Glendenning (1914) from *Stilpnotia salicis* in British Columbia.

Holotype.—Male, in collection of Mass. Agri. College. Paratypes are in the U. S. N. M.

Sarcophaga atlanis Aldrich

1916. Aldrich, *Sarcophaga* and Allies, p. 100.

Although this species may be confused with *hunteri* it may be distinguished by the black palpi and the lack of a tuft of long black hair which is found on each anal forcep of *hunteri*.

Length.—5 to 8 mm.

Records.—McLean; Herkimer; *L.I.*: Islip. June to August. Figures 134, 135 and 136.

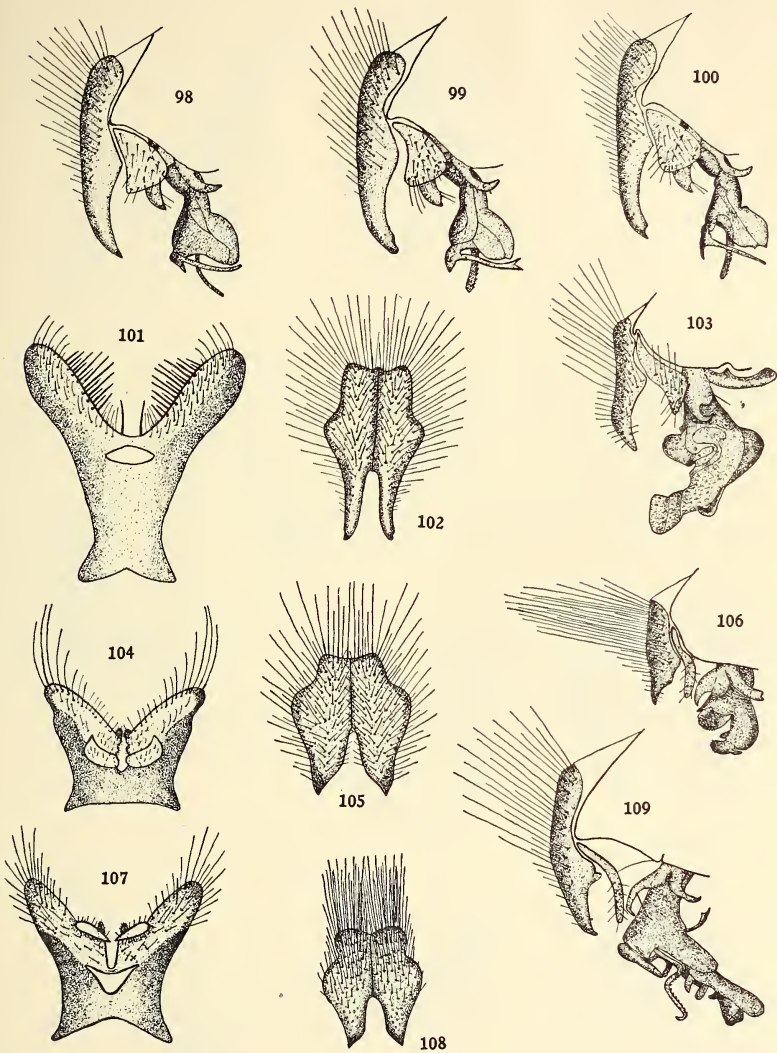
Aldrich (1916) pointed out that this species was a parasite of grasshoppers. Mr. J. W. H. Rehn very kindly permitted the writer to publish data taken during the summer of 1936 when he secured information by rearings to show that approximately 25% of the adults of *Dendrotettix quercus* P. at Mt. Misery, New Jersey were parasitized by *Sarcophaga atlanis*.

Holotype and allotype.—Male and female, No. 20506, U. S. N. M.

(To be continued)

PLATE VIII

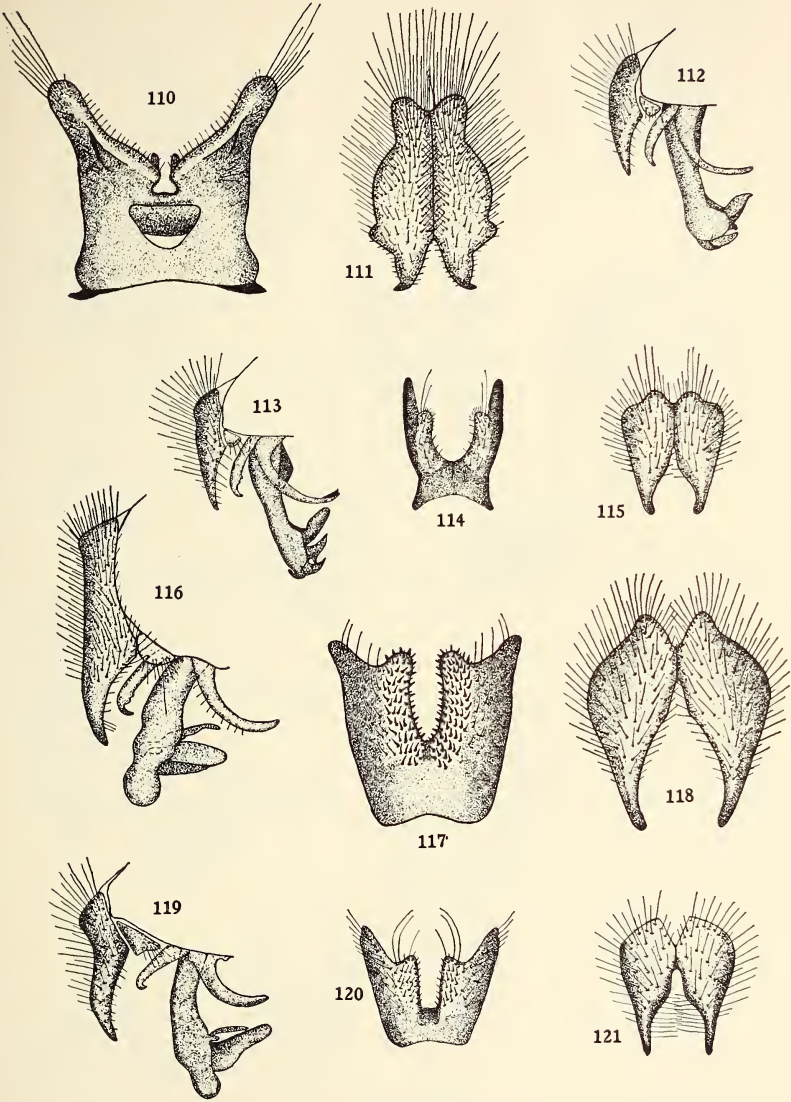
- Figure 98. Lateral view of external genitalia of *Sarcophaga misera* var. *exuberans* Pand.
- Figure 99. Lateral view of external genitalia of *Sarcophaga misera* var. *harpax* Pand.
- Figure 100. Lateral view of external genitalia of *Sarcophaga misera* var. *sarracenioides* Ald.
- Figure 101. Fifth sternum of *Sarcophaga misera* var. *sarracenioides* A.
- Figure 102. Rear view of anal forceps of *Sarcophaga misera* var. *sarracenioides* Ald.
- Figure 103. Lateral view of external genitalia of *Sarcophaga bisetosa* Parker.
- Figure 104. Fifth sternum of *Sarcophaga bisetosa* Parker.
- Figure 105. Rear view of anal forceps of *Sarcophaga bisetosa* Parker.
- Figure 106. Lateral view of external genitalia of *Sarcophaga cimbicis* T.
- Figure 107. Fifth sternum of *Sarcophaga cimbicis* Townsend.
- Figure 108. Rear view of anal forceps of *Sarcophaga cimbicis* Town.
- Figure 109. Lateral view of external genitalia of *Sarcophaga latisterna* Parker.



SARCOPHAGINÆ

PLATE IX

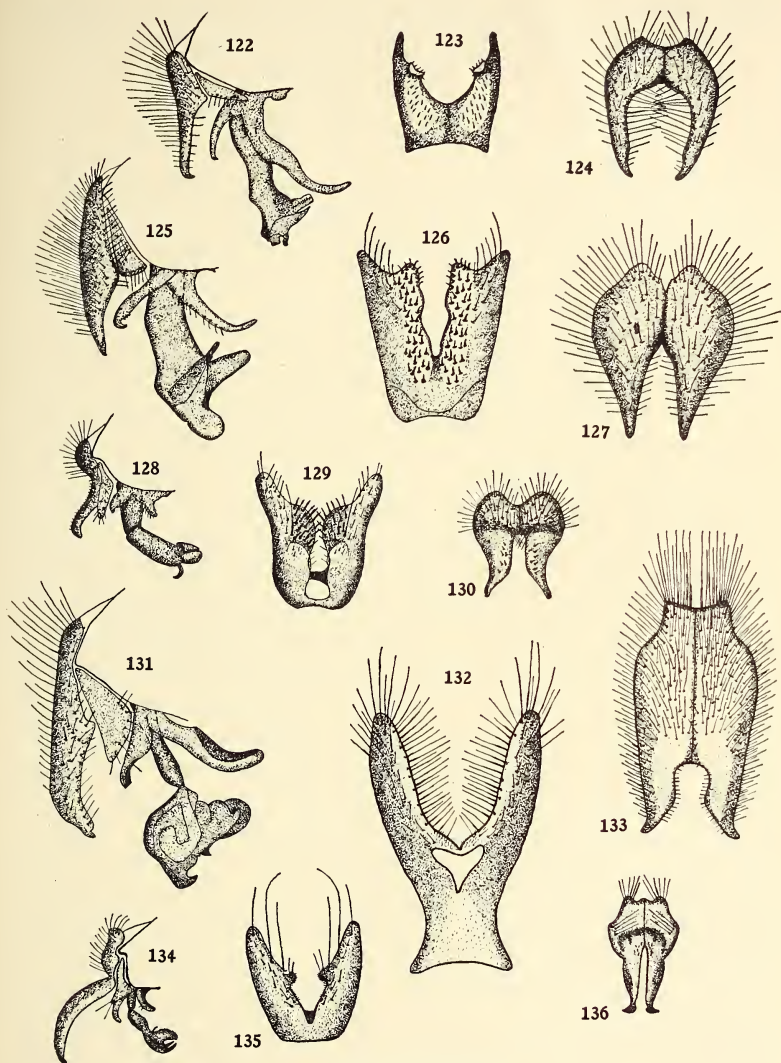
- Figure 110. Fifth sternum of *Sarcophaga latisterna* Parker.
Figure 111. Rear view of anal forceps of *Sarcophaga latisterna* Park.
Figure 112. Lateral view of external genitalia of *Sarcophaga laakei* Hall.
Figure 113. Lateral view of external genitalia of *Sarcophaga latisetosa* Parker.
Figure 114. Fifth sternum of *Sarcophaga latisetosa* Parker.
Figure 115. Rear view of anal forceps of *Sarcophaga latisetosa* Park.
Figure 116. Lateral view of external genitalia of *Sarcophaga l'herminieri* R.-D.
Figure 117. Fifth sternum of *Sarcophaga l'herminieri* R.-D.
Figure 118. Rear view of anal forceps of *Sarcophaga l'herminieri* Rob.-Des.
Figure 119. Lateral view of external genitalia of *Sarcophaga pusiola* V. d. W.
Figure 120. Fifth sternum of *Sarcophaga pusiola* V. d. W.
Figure 121. Rear view of anal forceps of *Sarcophaga pusiola* V. d. W.



SARCOPHAGINÆ

PLATE X

- Figure 122. Lateral view of external genitalia of *Sarcophaga stimulans* Walker.
- Figure 123. Fifth sternum of *Sarcophaga stimulans* Walker.
- Figure 124. Rear view of anal forceps of *Sarcophaga stimulans* Walk.
- Figure 125. Lateral view of external genitalia of *Sarcophaga sueta* V. d. W.
- Figure 126. Fifth sternum of *Sarcophaga sueta* V. d. W.
- Figure 127. Rear view of anal forceps of *Sarcophaga sueta* V. d. W.
- Figure 128. Lateral view of external genitalia of *Sarcophaga alcedo* Aldrich.
- Figure 129. Fifth sternum of *Sarcophaga alcedo* Aldrich.
- Figure 130. Rear view of anal forceps of *Sarcophaga alcedo* Aldrich.
- Figure 131. Lateral view of external genitalia of *Sarcophaga aldrichi* Parker.
- Figure 132. Fifth sternum of *Sarcophaga aldrichi* Parker.
- Figure 133. Rear view of anal forceps of *Sarcophaga aldrichi* Parker.
- Figure 134. Lateral view of external genitalia of *Sarcophaga atlanis* Aldrich.
- Figure 135. Fifth sternum of *Sarcophaga atlanis* Aldrich.
- Figure 136. Rear view of anal forceps of *Sarcophaga atlanis* Aldrich.



SARCOPHAGINÆ

OBSERVATIONS ON SILPHINÆ WITH A NOTE ON INTRASPECIFIC VARIATIONS AND THEIR DESIGNATION

BY MELVILLE H. HATCH

The following observations on Silphinae are supplemental to two previous papers on the same group.¹ I am indebted to Mr. Roy D. Shenefelt for permission to study the collection of Washington State College.

Apteroloma tenuicorne LeC.—While I have taken this species from as low an elevation as 1900 feet at Cle Elum, Washington, and Mr. M. C. Lane has taken it at about 1800 feet at Ritzville, Washington, it appears to be especially prevalent at somewhat greater elevations in extreme eastern Washington and northern Idaho. Thus I have a series of thirteen specimens taken by Mr. Lane at an elevation of about 4000 feet on Cedar Mt. near Moscow, Idaho, on May 25, 1935; and Mr. Clifford J. Burner and I secured fifty or more specimens on May 30, 1937, at an elevation of from five thousand to fifty-two hundred feet on Mt. Spokane, northeast of Spokane, Washington. In this latter situation the beetles occurred on the damp or wet ground under the edges of the melting snow fields.

Silpha (Thanatophilus) trituberculata Kby.—A second Washington specimen was taken by Mr. Joseph Bruzas near the Dry Falls of the Grand Coulee, May 7, 1938, and given to me.

Silpha (Thanatophilus) lapponica Hbst.—There are, in the Washington State College collection, two series of this species taken in Chicago by A. L. Melander and in "N. Ill." by F. M. Webster. This extends the range of this species in this direction and makes its absence from Indiana and southwestern Michigan more noteworthy than ever.

Silpha (Blitophaga) opaca Linn. and *bituberosa* LeC.—Essig²

¹ Hatch, Melville H. Studies on the Silphinae. JOUR. N. Y. ENT. SOC., XXXV, 1927, pp. 331-371.

Hatch, Melville H., and William Rueter, Jr. Coleoptera of Washington: Silphidae. Univ. Wash. Publ. Biol. I, 1934, pp. 147-162.

² Ins. w. N. Amer., 1926, pp. 381-383.

lists the first of these species from Alaska to California and the second from Washington. I have no knowledge of either occurring in Washington.

Nicrophorus (*Necropter*) *vespilloides* Hbst. (*defodiens* Mann. of Portevin and Hatch).—I follow Leech³ in his inability to distinguish specifically the Nearctic and Palearctic forms of this species and in his use of *defodiens* Mann., as a Pacific Coast subspecies of the same. Leech's notes are incorporated in the following revised tabulation of the Nearctic forms of this species, which should be used in connection with my original table:⁴

vespilloides Hbst. (*defodiens* Mann. of Portevin and Hatch)

typical form (*hebes* Kby., *pygmæus* Kby., *humeralis* Hatch)

ab. *ruber* Hatch

ab. *nearcticus* nov. (*defodiens* typical form Port. and Hatch, nec. Mann.)

ab. *nicolayi* Hatch

ab. *oregonensis* Hatch

subsp. *defodiens* Mann.

typical form (*nunemacheri* Hatch, *nunenmacheri* Leech)

ab. *binotoides* nov. (*binotatus* Hatch nec. Port.)

ab. *conversator* Walk. (*defodiens* var. b of Mann., *lateralis* Port.)

ab. *pacificæ* Hatch

ab. *gaigei* Hatch

ab. *walkeri* nov. (*conversator* Port. and Hatch, nec. Walk.)

ab. *kadjakensis* Port.

ab. *mannerheimi* Port.⁵

ab. *binotatus* Port.⁶

It should be noted that, with the exception of the typical form, none of the Nearctic aberrations of *vespilloides* occur in the Palearctic Region and that, moreover, the types of variation in the two regions are very different. None of the Palearctic aberrations, for instance, appear to lack an orange spot from the base

³ Bull. Brook. Ent. Soc., XXXI, 1936, p. 156.

⁴ Hatch, Jour. N. Y. Ent. Soc., XXXV, 1927, p. 356.

⁵ The anterior elytral fascia in this aberration is divided into two. I was in error in describing it as constricted.

⁶ The posterior elytral spot is absent, the anterior fascia reduced to a single spot in this aberration.

of the epipleuron,⁷ which is lacking in all the American aberrations except the typical form and the ab. *ruber*. Leech⁸ suggests that the subsp. *defodiens* extends to Japan, and the ab. *sylvivagus* Reitter from that locality may be referable to that subspecies, apparently resembling the ab. *lateralis* Port. On the other hand, *sylvivagus* is, according to Portevin,⁹ related to the eastern Asiatic varieties, *borealis* Port. and *sylvaticus* Reitt., in which the abdominal pubescence is yellow rather than black.

Leech's observations¹⁰ on the habits of *defodiens* are of great interest. They confirm to a surprising degree those previously published by Pukowski¹¹ for a series of European species, including *vespilloides*. These observations of Pukowski's are abstracted at length in English by Balduf in the *Bionomics of Entomophagous Coleoptera* (John S. Swift and Co.), 1935, pp. 69-75.

Nicrophorus (Necropter) investigator Zett. subsp. *investigator* Zett. and *nigritus* Mann.—I have now seen examples of both these forms from Pullman and the latter in addition from Spokane and Wawawai, all in eastern Washington.

Nicrophorus (Necropter) guttulus Mots.—Of the subsp. *guttulus*, I have a single example of the ab. *vandykei* Angell from Pullman and ab. *woodgatei* from Port Townsend, both in Washington.

INTRASPECIFIC VARIATIONS AND THEIR DESIGNATION¹²

Intraspecific variation should be studied for the following reasons:

(1) The fundamental obligation of taxonomy is to describe accurately and precisely the variation presented.

⁷ This term is, according to Torre Bueno's *Glossary of Entomology*, 1937, pp. 92, 132, definitely superior to "*hypomeron*," which I used formerly.

⁸ *L.c.*, p. 156.

⁹ Bull. Mus. Paris, XXX, 1924, p. 375; Encycl. Ent., VI, 1926, p. 235, 259.

¹⁰ Proc. Ent. Soc. B. C., XXXI, 1935, pp. 36-40.

¹¹ Zeit. Morp. Ökol. Tiere, XXVII, 1933, pp. 518-586.

¹² These remarks are supplemental to my original statement in JOUR. N. Y. ENT. SOC., XXXV, 1927, p. 341, and are largely prompted by Leech's comments on my classification of the aberrations of *Nicrophorus vespilloides* subsp. *defodiens* Mann. in Proc. Ent. Soc. B. C., XXXI, 1935, pp. 36-40, and Bull. Brook. Ent. Soc., XXXII, 1937, pp. 156-159.

(2) What appear at first to be intraspecific variations are frequently the elements out of which subspecies and species are later recognized. The indication of such forms by one author, though he holds them to be entirely intraspecific in nature, may enable a subsequent author to reach conclusions of a very different sort.

(3) Many intraspecific variations are the materials out of which new species evolve in the course of geologic time. Their detection and study is the first step in their consideration as factors in evolution. To argue that this is more suited to genetics than to normal systematic entomology¹³ is to adopt a wholly untenable view of the discreteness of taxonomy from other branches of biological knowledge. It is in important measure the taxonomist passing in review large series of different life forms who is in a position to discover this sort of data.

There are several ways in which intraspecific variation may be treated.

(1) It can be entirely ignored! Every working taxonomist can probably bring to mind descriptions in highly variable groups which mention only the supposed specific characters with never a word as to the variation.

(2) Then there is the traditional method, which is a prevalent procedure in America, of devoting a special paragraph to the intraspecific variation. This method is applicable to strictly continuous variation, where it can be supplemented by curves of variation and other graphs. It is also useful where the variation is vague or extremely complicated. When applied to more or less discontinuous variation, it shows that the study of the variants is in an early pre-Linnæan stage, since subsequent references to the variations mentioned must repeat the entire definition of the variety.

(3) The early coleopterists lettered intraspecific variations. Thus Illiger, in his *Verzeichniss der Käfer Preussens* (1798), and Schönherr, in his *Synonymia Insectorum* (1806-1817), and LeConte as late as 1880 gave Greek letters to their varieties, "alpha" being reserved for the typical form. The current pro-

¹³ Leech, *l.c.*, p. 39.

cedure would undoubtedly be to substitute Latin for Greek letters, and I have employed letters myself on several occasions.¹⁴

(4) The transition from letters to names was gradual. One author would describe a species which another author would regard as a variety. The extra name would be retained as a varietal name and the tendency would be to invent new names for other varieties of similar rank.

For about half a century continental coleopterists have employed the term *aberratio* (English, *aberration*) to apply for the most part to color varieties. Most of their valid species were described, so they turned to the problem of intraspecific variation. Aberrations were used by Ganglbauer in *Die Käfer von Mitteleuropa* in 1892 and are to be found employed in practically every continental work on coleopterology that has appeared since 1900, but only during the past decade has this usage made much headway in English speaking countries. Leech¹⁵ finds the term so unusual that he puts it in quotation marks and there is an unfortunate tendency¹⁶ in some quarters to substitute the English for the Latin meaning of the word and thus limit it to freakish, monstrous specimens. In reality the word is to be derived from the figurative use of the verb *aberro*, "to wander, deviate, depart from."

There has been a general tendency to regard all intraspecific names as being nomenclatorially on a par with specific and subspecific names,¹⁷ and this is, perhaps, one of the chief sources of the prejudice against them. Many systematists have disliked seeing names based on trivial or supposedly trivial features on a par with names based on supposedly fundamental characters. There is, accordingly, some cogency for:

(5) The procedure suggested in the *Entomological Code* of Banks and Caudell (1912, p. 9, sec. 37) and that of the British National Committee on Entomological Nomenclature¹⁸ releasing

¹⁴ Tech. Publ. N. Y. St. Coll. For., 17, 1924, p. 307; Univ. Wash. Publ. Biol., I, 1932, p. 100.

¹⁵ Bull. Brook. Ent. Soc., XXXII, 1937, p. 158.

¹⁶ Gunder, Ent. News, XXVIII, 1927, p. 265; Carter, Ann. Mag. Nat. Hist., 104, 1934, p. 552.

¹⁷ This is my own preference.

aberrational names from the application of priority. The British code would release them entirely, the Banks and Caudell code would require priority to operate within the limits of the single species.

(6) The logical consequence of releasing aberrational names from the operation of priority are the somewhat similar proposals of Blaisdell¹⁹ and Heikertinger²⁰ who suggest the use of descriptive or semi-descriptive words in place of aberrational names, these words being used over and over again in different species even of the same genus as often as required, being purely descriptive, and absolute synonyms of ordinary specific and varietal names entirely free from the operation of priority or other nomenclatorial rules. Blaisdell called the category to which he applied these names a "forma," employed words like *typica*, *glabra*, *interstitialis*, *punctata*, *annectans*, *catalinae*, *communis*, *emarginata*, *borealis*, etc., and accompanied them with descriptions. He used them in connection with his monograph of the Eleodini referred to above, and where it has become subsequently desirable to elevate some of them to the rank of variety or species, he considers²¹ the names so used to date from the time of their elevation rather than from that of their original proposal.

Heikertinger calls his terms "Kennworten," "recognition words," and has attempted to use words of self-evident meaning, not requiring attendant descriptions. He works out this suggestion in the Halticinae section of Winkler's *Catalogus Coleopterorum regionis palaearcticae* (1930, pp. 1317-1352), using terms like *viridicollis*, *ruficollis*, *vitipennis*, *maculipennis*, *nigrosuturata*, *latilimbata*, etc. Heikertinger's system would appear

¹⁸ Proc. Ent. Soc. London, III (1), 1928, p. 11R.

¹⁹ U. S. Nat. Mus. Bull., 63, 1909, pp. v-vi.

²⁰ Kol. Rund, XV, 1930, pp. 213-230. In this connection it is interesting to note the suggestion of Croneis in Science (LXXXIX, 1939, pp. 314-315) of a series of categories paralleling the Linnæan ones for use in classifying fossil remains whose true biological affinities are not ascertained. This is significant as an insistence that taxonomy not neglect its basic function of describing, classifying, and designating for the important but sometimes impossible task of interpreting. Hubbs' arguments (Science, LXXI, 1930, pp. 317-319) in favor of a uninomial as opposed to a binomial system of species designation is another suggestion looking in the same direction.

²¹ Pan-Pac. Ent., II, 1925, p. 77.

to be applicable only to relatively simple types of variation rather than to those involving complicated color pattern changes.

(7) For complicated color pattern variations formulæ can be used. The spots or other elements of the pattern are numbered or lettered, various combinations of these symbols indicating the different forms. This system was used by Johnson in *Coccinellidæ*²² and I have myself employed it on several occasions.²³

(8) The ultimate stage in the nomenclature of intraspecific variation is attained when it can be defined in terms of the constituent genes or other hereditary or environmental factors involved. This is possible at present for only a very few species, like some of the *Drosophila* and a few of the *Chrysomelidæ* and *Coccinellidæ*.

The principal requirement of a nomenclature for intraspecific variations is that it be clear cut, unequivocal, and of such a nature as to make it possible for subsequent authors to refer to the forms described precisely without having to repeat the entire description in pre-Linnæan fashion. Any one of the last six methods cited is available with the second one in reserve for vague or imperfectly understood variation. Whether one uses numbers, letters, formulæ, or names with or without priority, or all in combination, is of secondary importance so long as is met the initial requirement of precision.

Objections to studies of intraspecific variation are voiced on various grounds. It is said that many variation studies, especially those involving scarcely more than the pointing out of the existence of the several variations, are of little value because of their superficial preliminary nature, because they are confined to a single prominent variable character, or because no attempt is made to correlate them with the environment or heredity of the form under consideration. One might equally criticize the describer of a new species because he fails to work out its life history or genetics before going on to the next species. These problems are important and some day will be studied by somebody. But the task, or one of the tasks, of taxonomy is a descrip-

²² Johnson, Roswell H. Determinate evolution in the color-pattern of the lady-beetle, Carnegie Inst. of Wash. Publ. No. 122, 1910, 104 pp.

²³ JOUR. N. Y. ENT. SOC., XXXV, 1937, pp. 347-348; Univ. Wash. Publ. Biol., I, 1932, pp. 98-99.

tive survey of the animal kingdom—a survey that would be indefinitely delayed if each investigator attempted to see each of his problems through to an ultimate ecological or genetical conclusion. It is stated, again, that such studies are “genetics” rather than “normal systematic entomology”! They are criticized because they are of no use to the economic entomologist.²⁴ Apparently “normal systematic entomology” may “make up” to the economic entomologist, but must “shy off” from the geneticist!

One of the main results derived from designating a form an aberration or color variety or forma is that it is thereby almost certainly removed from the attention of the economic entomologist and the general ecologist,²⁵ except as they find it convenient not to be led astray by extreme phases that the species may assume, melanistic, immaculate, or depauperized forms that might at first be mistaken for distinct species. The classification of aberrations is usually of no more significance for such persons than, for instance, the designation of sex; in fact, it may be of far less importance, since the recognition of the sexes is of practical concern in many experimental procedures. Thus, in citing an insect like the asparagus beetle, *Crioceris asparagi* L., for the *Insect Pest Survey Bulletin*, it would be absurd to give more than the species. The numerous aberrations of the asparagus beetle²⁶ and other species are available for those who need or are interested in such matters; they may be overlooked by others.

A more cogent objection to the validity of studies in intraspecific variation is that such variations may intergrade; they may intergrade in series, the right and left side of the body may exhibit different variations, different variations may occur in the progeny of the same pair of parents.²⁷ A good deal of the force of this objection is due to a misapprehension. The principal difference between species and intraspecific forms of all sorts is that the

²⁴ Hopping, Proc. Ent. Soc. B. C., XXXI, 1935, p. 34.

²⁵ The person making a detailed ecological study of a single species may be very much interested in aberrations, especially if any of them prove to have an origin that is immediately environmental.

²⁶ See Hatch, Bull. Brook. Ent. Soc., XXII, 1927, p. 211; Univ. Wash. Publ. Biol., I, 1932, pp. 72-74, for some account of these aberrations and their literature.

²⁷ Leech, *l.c.*, p. 158.

former are characterized by an absence of intermediates, at least in theory. If the intraspecific variations were marked off as distinctly as it is intimated they should be, they would not be intraspecific variations but species.

The matter, then, comes to this: Is it worth while to attempt to distinguish characteristic phases of a more or less continuously varying series? And, if we do, what is to prevent us from running off into non-significant "unnamables" and individual variants? The question of "unnamables" in Lepidoptera has been discussed by Gunder²⁸ and Forbes²⁹ and should offer little difficulty in the long run. Unless the causes of the variation have acted from within the living organism,³⁰ the forms produced are clearly of little significance³¹ for the student of intraspecific variation. Moreover the variation must be of such a type that it occurs or probably occurs in series. Otherwise it is "individual" or "unnamable." Even as regards size, it is sometimes convenient to designate minor or depauperized specimens, especially when this is accompanied by the specific characters in an enfeebled form.

Leech (*l.c.*) specifically questions the utility of distinguishing four stages in the disintegration of the anterior elytral fascia in one of the Pacific Coast forms of *Nicrophorus*. In 1927 I described these and other aberrations of this species on the basis of series too small to show their nature. In 1934,³² in a series of 178 specimens from western Washington, I showed that these four stages form an approximately normal curve of variation with the apex of the curve close to one of the intermediate types. Leech could have continued the analysis in other portions of the range. He preferred, however, simply to express the view that such a study, based on color pattern variation alone, was without signifi-

²⁸ Ent. News, XXXIX, 1928, pp. 201-204, pl. VII-X.

²⁹ Bull. Brook. Ent. Soc., XXIX, 1934, pp. 65-67.

³⁰ By which I do not mean to limit the causes to hereditary ones. Environment may, for instance, produce melanism, which I would tend to regard as "significant."

³¹ I prefer "significance" to "nameability" because, throughout the present discussion, I maintain that whether a variant is "named" or merely designated by a number, letter, or formula is of no importance.

³² Univ. Wash. Publ. Biol., I, 1934, p. 158.

cance, and a large number, perhaps the majority, of American coleopterists would agree with him.

The principal objection to studies of intraspecific variation is not directed against the studies as such but against the *naming* of the variations. As has been noted, the author's contention is that whether or not the variants are named is a matter of secondary importance, so long as they are precisely designated. This, however, is not the view of opponents of names of this class. They consider the so-called "cluttering up" of the literature with such names an offense than which scarcely any other is greater! as though *naming* a variant could give it any importance and dignity it did not have before! Names are merely combinations of letters—symbols for designating biological concepts. They are symbols, however, that, because of their great associational powers, are so much more convenient than letters or numbers or formulæ that the tendency to use them for this class of variation is very great. They, varieties, color varieties, aberrations, forms—the precise term applied is of little moment—named or merely designated—should be taken at their face value for exactly what they are—categories intermediate between the subspecies and the individual.

Where then are we going to stop? Lacking data derived from genetical experimentation, we must depend on our judgment. The benefit of the criterion of the presence or absence of intermediate specimens is denied to us, since all intraspecific variations are subject to such a connection. Forbes (*l.c.*) suggests that if we can recognize 90 per cent of the specimens from a given area as belonging to a given geographical race the race is valid. Perhaps that or some other percentage will serve for the recognition of aberrations. The matter is really akin to that of genera and subgenera. As many are recognized as are convenient. And the number, as with the higher taxonomic categories, is almost certain to increase as more and more extensive series of specimens are passed in review and more and more precise methods of study are employed.

There seems to be concern in some quarters that a continued accumulation especially of named varieties, aberrations, etc., will involve the literature in hopeless confusion. Such a fear is

groundless. The matter is self-correcting, just as is the over multiplication of categories at any of the other systematic levels. Only such designations persist as subsequent authors find recognizable and useful. Authors who do not care to pay attention to non-geographical intraspecific variations ignore them, treating such names as may have been proposed as *absolute synonyms*, which, indeed, they truly are, *from their point of view*. Other authors, who are interested in such categories, recognize as many of their predecessor's "designants" as the nature of the characters cited in the original descriptions or inherent in the types, where types are available, and the nature of the organisms themselves permit—exactly as with categories of other types. It is probably too much to expect that there will be any cessation of vituperativeness between persons holding different views!

The whole matter may come down to personal preference. But the growing continental usage would seem to indicate that, as the beetle fauna becomes better and better known, more attention is directed to intraspecific variation.

Studies of these intraspecific categories may be largely overlooked by the economic entomologist and the ecologist, and must be overlooked by the naturalist whose aim is simply to get into his cabinet a "set" of two, six, or any other fixed number of specimens of each species. They are, however, almost inevitable for the student who desires to study his material with some regard for its complexity—an inadequate forecast of the time when taxonomists will analyze their species genetically.

SUMMARY

It is held that intraspecific variants, such as varieties, color varieties, aberrations, forms, etc., should be as precisely described and designated as the material will permit. Whether this designation is accomplished by means of numbers, letters, formulæ, or names with or without priority is secondary. The author prefers to allow the principal of priority to operate as generally as is conveniently possible, but this likewise is a secondary consideration.

I must not close this discussion without acknowledging the invaluable critical assistance I have received in its preparation

from two of my former students, Dr. Donald L. Frizzell and Dr. Harriet Exline Frizzell; especially the former, neither of whom, however, are responsible for any of the opinions expressed herein.

A NEW RECORD FOR CONNECTICUT

Along a wooded road near Sharon, Conn., on June 16, 1940, a small skipper, *Carterocephalus palaemon*, race *mesapano* Scudder was discovered. This is a rather unusual record for this butterfly which hardly ever occurs south of the Adirondacks or the White Mountains. So far as is known, this is the one and only instance that it has ever been found in Connecticut.—LEONARD J. SANFORD.



SOME ASPECTS OF MODERN TAXONOMY*

BY RICHARD E. BLACKWELDER

It should not be necessary to define for the readers of this journal the word taxonomy. Perhaps we have not each taken the trouble to think out what it means to us, but we nevertheless understand it well enough. I was therefore somewhat surprised recently to find out that I was attaching to the word in my own thoughts certain meanings which it did not hold for some other taxonomists to whom I talked. So I desire to make it clear that I am now using the terms taxonomy, classification, and systematics as absolutely synonymous, since they all inherently refer to the science of arrangement or classification.

The study of taxonomy in its broadest sense is probably the oldest branch of biology or natural history as well as the basis for all the other branches, since the first step in obtaining any knowledge of things about us is to discriminate between them and to learn to recognize them. It is therefore natural that for the first one hundred years or more of the existence of this branch as a science, it was concerned primarily with the segregation and recognition of species. The direct results of this trend are sometimes underestimated, for they include the following among others: First, taxonomists made known some idea at least of the tremendous number of organisms that exist or have existed upon the earth. This fact has had a very great influence on some of man's long-established and much-cherished conceptions. In particular, it gave a very great impetus to the warfare of science with theology. Second, the knowledge accumulated by the taxonomist was the principal basis for Darwin's "Theory of Evolution." It is not necessary for me to point out the tremendous affect on human thought which was produced by that series of studies. Third, taxonomists have built up an enormous mass of knowledge which is in some degree classified and available. The system is far from perfect, we must admit, and many of its parts are of very inferior quality, but, nevertheless, the general pattern has stood the test of time and has proved its usefulness. Fourth,

* Delivered before the New York Entomological Society, December 12, 1939.

taxonomy has furnished to other biologists many of the fundamental questions to which they are seeking answers. The geneticists and experimental biologists spend much of their time on problems which are fundamental to taxonomy today and yet were recognized because of the implications of studies on classification and evolution.

We might multiply these examples at some length, but surely this is sufficient to show that taxonomy during its early years was a worthy subject for research, and that it did actually contribute greatly to the advance of knowledge in many fields.

As I have said, there was a time when taxonomists made large contributions to scientific thought through the mere naming and cataloging of species. As the other branches of biology developed, the relative importance of this study of faunas and floras diminished, not because fewer people worked at it, not because there was less work to be done, not because there were fewer contributions to scientific thought to be made, but simply because the growth of these other branches was more rapid, and they surpassed it in popularity and possibly in the quality of the work. We must then consider whether taxonomy is no longer capable of contributing to biologic science, whether it has lost its position of fundamental importance among all the branches of biology.

In a practical way, then, let us outline the place of taxonomy at the present time. Consider the plight of experimental biologists, geneticists, students of geographical distribution, stratigraphers, and workers in the applied natural sciences if they had no means of recognizing and recording the various species with which they deal. It would be absolutely necessary for them to develop for themselves a system that would serve them and they would therein become systematists. How could the tremendous mass of experience be recorded and consulted without the taxonomists to name, identify, and classify the organisms with which all the others deal. A few examples should not be out of place here. Many problems of the geologist have been solved at least in part by the taxonomist. Properly used, the distribution of animals can aid in the problem of the distribution of ancient land masses and the seas of past geologic eras. Stratigraphy, or the correlation of rock formations, depends in large part on the recognition

and classification of fossil organisms. The physical anthropologist, with his problems of human races and human origins, is merely a specialized taxonomist working in a very limited field. Many problems of the geneticist, such as the recognition and separation of mutants and the experimental unfolding of the processes of evolution, are really specialized problems in taxonomy. I have not mentioned the sciences of comparative anatomy, embryology, and evolution which are so closely interwoven into taxonomy that frequently they must be considered to be part of it.

There remains a branch of biology which is of unusual interest to many entomologists. This is applied biology. Just as the discrimination of species is the basis of systematic work, it is also the starting point of many of the problems of the economic entomologist. If an insect pest be discovered, taxonomy tells us whether it is native or introduced, what its natural enemies are, where they will be found, what its normal distribution is, and many other things. Without taxonomy how could we have biological control, which depends upon identification of both the pest and the parasite or predator.

We have then several aims in systematic biology which are also our basis for a claim to recognition as one of the important sciences. It is our aim first to name and describe species so that they can be recognized and referred to, so that we may study them and catalog them, and assemble data about them. It is our second aim to discover through any means at our disposal the facts of descent and blood-relationship between species. And our third aim is to arrange these facts and these species into a classification or scheme of arrangement which will express as nearly as can be the relationships and the lines of descent of these species.

It is obvious that if we merely assemble a multitude of data concerning a multitude of species, we ourselves, not to mention scientists in other fields, will be unable to comprehend the larger implications of our discoveries, the interrelation of them, and their vast significance in related studies unless we arrange them in some sort of order, one based on some fundamental concept to which all are related. The concept which we have used for this is the theory of evolution, the assumption of the community of

descent of organisms. We will return to this subject of classifications after considering the means to be employed in fulfilling the aims we have outlined.

In the study of the relationships of insects, which we call taxonomy, data from various sources have been used. Among these we find characters of morphology, of geographical distribution, of geological distribution, of genetics, of ontogeny or development, of ecology, of physiology (which includes chemical and serological studies), of host-parasite relationships, of teratology (or deformities), and of experiment. All of these have been used in defining species or in building classifications, but by far the greater number of species and classifications are based entirely upon the first one—morphology. This is at it should be, since it has been found that none of the others yields as readily as complete a picture of relationships as does structure. The other fields are employed in special cases in which morphological data are not sufficient. There is a real danger, however, that taxonomists will forget that morphological data do not invariably furnish us with the complete picture. We should remember that situations can easily arise in which data from the other fields can be properly and usefully utilized to supplement the characters of morphology.

Still more important, however, is an understanding of the inescapable fact that the taxonomist is absolutely bound to consider all the data that may be of value in whatever problem confronts him. If we had, for example, spread out before us, all the species that exist on the earth of a certain group of animals, it would suffice for some purposes to select one or two characters that distinguish each from its fellows, and consider that these were enough to make the species known. In actual practice, however, we can never say with certainty that we have all the species that exist before us and the best of us will often not be able to anticipate what the missing ones will be like. It therefore becomes necessary for us to record all the characters of each species that can be of use in separating it from the others (whether known or not). In most cases and particularly in the case of categories higher than species, a careful study of comparative morphology of the group will show definitely which characters are of sufficient constancy to be used for separating the known groups, and these are the ones which we must record.

The ideal, then, is to record in each instance all the characters on the insect which the study of comparative morphology shows to be significant for the systematic work at hand. It should not be necessary for me to point out how far from this goal nearly all of our taxonomic work today really is. But inasmuch as the commonly accepted standards do not come even close to fulfilling the above requirement, let us pry a little into the reason for this failure.

During the early years of the study of taxonomy the investigation of insects was strictly limited by the equipment available. Microscopes such as we use today were unknown, and technique of various sorts had not been discovered. Many of the early taxonomists strived toward the goal of recording all the characters that they could see, and, because of the limiting factors mentioned above, a certain standard of description was gradually set up. Taxonomists became used to these standards and when better apparatus and techniques were devised they were not commonly utilized. The result is that the large majority of our systematic work today is at exactly the level of much of the better work of 100 years ago. For example, it is difficult to find among modern studies on Coleoptera one which can stand comparison with that of Erichson in 1840. This is not an exceptional case, for the majority of large groups of insects are being studied today in exactly the same way and in only slightly greater detail than they were 50 or 100 years ago.

Two things seem to be responsible for this situation. The first is our reticence to change our methods of study. It is not possible to examine the intersegmental membranes of the abdomen of a beetle, or the waxy capsule of a scale-insect, or the musculature of any insect, or the minute dermal organs which are so commonly present but so seldom seen, or any of hundreds of other structures, without subjecting the insect to some preparation or technique which is not commonly employed. Yet these structures are of great significance in nearly every group in which they have been studied and often are clearly worthy of consideration in our scheme of classification. We have simply been content with the established way of doing things and have forgotten our ideal of constructing a classification that will reflect relationships and which, therefore, must utilize all possible characters.

The second factor which has held our descriptions down to the old standards is the lack of knowledge of comparative morphology. Is there a single large order of insects in which the fundamental nature of all the parts has been worked out and in which the variation of each character throughout the group has been determined? It is certainly not so in the beetles, one of our best known orders in some respects. If it is true of any order the fact has escaped me. Several smaller groups, such as the Coccoidea, do come near to this ideal.

Ten years ago it was not known that the order Coleoptera contains two radically different types of thoracic structure. Even at the present time there are numerous questions of homology that have not been settled in this order or any of the others. If we should look at a complete series of drawings of the morphological details of a beetle, I think you would be surprised at the number of structures which have not been used in classification, and yet this condition is typical of nearly all the orders.

Let me recall to you the ideal which I mentioned before for finding the characters we are to use in reconstructing the relationships of species. We must use all the characters which the study of comparative morphology shows to be significant. We are exceedingly far from that ideal.

In addition to the segregation and description of species the taxonomist should be engaged in something much more far-reaching in science, something which will be more universally accepted as a truly scientific endeavor. This is classification. It is the arrangement of species into groups to show their relationships. The groups are then brought together into larger groups and so on, until the degree of relationship is expressed by the category in which union takes place. In spite of the fact that the organizing of our data into systems or classifications, into a form which will make it useful in other branches of science, is much the most important part of taxonomy from the point of view of the advance of knowledge, entomologists have been very slow to make contributions of this sort. If a certain group of animals, for example an order, has been so thoroughly studied that a complete classification is available, with definitely known and described categories throughout, all we would need to do upon the

discovery of a new species would be to describe it and place it in its proper genus. This would automatically place it in the rest of the system. In reality this is the way in which many taxonomists appear to work. The assignment of a new species to a genus is taken to be sufficient indication of its relationships. I venture to say that there is not a single large order of insects in which there is more than the flimsiest classification in the sense that I have tried to give to that word.

Let me illustrate with an example from my own field, the Staphylinidæ. In the very large subfamily Aleocharinæ there has been a large amount of work done by several prolific taxonomists. They have established more than 1000 genera, which contain over 7000 species. New species are being added continually and each is being placed by its describer in what he deems to be its proper genus. There is nothing unusual in this; it is being duplicated, perhaps on a smaller scale, in many other groups of insects. However, if we take the trouble to probe more deeply, we may be surprised to find that not a single one of these 1000 genera has ever been *adequately* described, and many of them not described at all, being based merely upon known species. And further, when we examine other groups we find that this is not an exception drawn from a badly neglected group but is in fact the "normal" condition, or at least the "usual" one. In a family which is as well known as the Coccidæ, the scale-insects, a study of the genera is even now being published that will for the first time enable us to make generic assignments with certainty. The large amount of taxonomic work which has been done in this group and its great economic importance would have led us to imagine that its classification must by now be on a firm basis, yet a recent article on the subject states: ". . . the student of the Coccoidea . . . is forced to wander in a maze of generic names the application of most of which can not be determined from the existing literature." If this is true in the Coccidæ, where can we find a group which can claim to be better known in these respects. Certainly not anywhere in the Coleoptera.

How can we have any confidence in the validity of the horde of new species that are described each year if we know in ad-

vance that their generic assignments are based entirely upon the author's conception of the genus to which he assigns it. How often is the same species described in different genera by different workers, merely because the genera have never been firmly established? As one would expect, it happens with great frequency in groups of wide distribution and accounts for a large part of our overburdened synonymy.

You may think that I have painted a very dark picture. But it is a picture of a condition which exists and which will continue to exist until taxonomists take the necessary steps to correct it. I am glad to be able to say that there is evidence of increasing realization of the seriousness of this condition, and there are an increasing number of attempts to help correct it. I have mentioned the study of the genera of the Coccidæ, and we may note also an increasing number of studies of genotypes and of groups of genera. There have even been a few studies on the principles and bases of higher classification. This is the track that we must follow if taxonomy is not to continue to merit the bad reputation it has acquired among biologists. We must be more than mere describers of new species and lawyers on arbitrary points of procedure.

There is one more point that should be mentioned in this regard. A division of labor is not the solution of this problem. It will not suffice for us to describe new species *ad infinitum* and leave the classification to someone else. We cannot possibly claim to know that a species is new unless we know definitely where it belongs in our classification. And we will have a hard time to justify our labors to science in general if we do not complete our work so that the results are available for others to use.

If I have succeeded in convincing you that our taxonomy has fallen far short of its ideal and that we come close to deserving the scorn of our fellow biologists, if I have established in your minds the idea that taxonomy must be more than the mere description of new species, then you will ask what is to be done and how can we do it. My answer is, of course, that we must make classification a major part of our work; we must arrange our knowledge, as our species, in a system which will express what we have been able to discover, by all means in our power, of their

interrelationships, of their origins and potentialities, and consequently of their evolution. This is the logical goal of systematic work and one which is in all respects fully worthy of our endeavors. If we can attain this goal we will find that most of our other problems in taxonomy, such as the identification of species, will be solved as by-products of the major problems. Let us see, then, what a classification is and how it is made.

A classification is a grouping or arrangement of things with regard to some group of attributes. We can classify insects according to their food, their place or means of living, their distribution in space or in time; or by their structure. In taxonomy we are interested primarily in a classification based upon amount of similarity in structure because we believe that this will give us the truest and most complete picture of lines of descent and degree of relationship.

There are two principal methods of recording a scheme of classification. They have different uses and different advantages and disadvantages. The first is a purely linear arrangement. We place the most primitive at the first of our list, next to these the ones which resemble them most, then the next, and so on to the most highly specialized. Our arrangement is rather arbitrary because one group must follow after another. Relationship can be shown with only two other groups, the one preceding and the one following, and it is not possible to give any indication of the degree of relationship, the amount of similarity. This system is most commonly employed because it is readily adapted to printing. Examples are to be found in all our catalogs and check-lists and all our textbooks of taxonomy.

The other system of recording a classification is by means of a branching arrangement, usually called a "tree." There are two kinds of trees in use. The most familiar is that used in paleontology to indicate the relationships of animals in time. As one passes down the time-scale the various groups merge to form a tree which indicates in some measure the degree of relationship, the time at which the separation of the two groups occurred, the number and proximity of related groups, the lines of descent, and perhaps even the ancestors of each group. This tree is generally based upon very meager information, but is useful and illuminating in proportion to its accuracy.

The type of tree which can help us most is one which we see very seldom in entomological literature. It is not of exceedingly great importance in itself but serves several very useful purposes—or might serve them. Its preparation would crystallize and demonstrate many of the broader aspects of classification in the mind of the creator of the tree. It would enable other entomologists as well as other scientists in general to see the results of the detailed work of taxonomy. This type of tree is in a strict sense “a classification.” I do not want to start a discussion of what a species is, so let us take the word species as each of you would define it for yourself. Among these species those which have certain characters in common we group together into a genus; genera which are more like each other than they are like still others we group together into a family; and so on through orders, classes, phyla, and kingdoms. This is a classification. If we examine simply the species, they appear in a linear arrangement but the other categories can show us the degree of interrelationship and can bring this meaningless series of species into a system in which each is related by one degree or another with every other.

Such classification as this gives us a broad picture which includes not only our own species but all the others as well, relating them to each other and to the entire scheme of life and of evolution. Such a classification can help to demonstrate to us inconsistencies in our use of such categories as genus and species, it can demonstrate the need for a real understanding of the higher categories and the limits of each.

It is obviously not practicable to draw diagrams of this sort for all the groups of insects. But it is not the diagram that is of value so much as it is the idea of relating our groups to each other by means of successively higher categories. For example: In one subfamily of the Staphylinidæ we have four readily recognized groups which have all been named as tribes, thus: Xantholinini, Staphylinini, Xanthopygini, and Quediini. There is no question that these groups exist and that they are more like each other than any of them is like any of the other subfamilies of the Staphylinidæ. At first glance then it would seem to be adequate to rank them all as tribes as has been done heretofore.

However, careful examination of many characters shows that the Xantholinini differ more from any of the others than they do from themselves. Some writers, recognizing this, have made it a separate subfamily, but I have already pointed out that it is more like the rest of the subfamily Staphylininae. If we separate it, we obscure the fact of its similarity in subfamily characters, and if we make it a tribe we obscure the fact of its greater divergence.

What is really needed in this case is another category between subfamily and tribe—we may use supertribe. This is what we get then: The subfamily Staphylininae composed of two supertribes, the Xantholinina and the Staphylinina. The Xantholinina contains only a single tribe, the Xantholinini, but the Staphylinina contains three tribes, the Staphylinini, the Xanthopygini, and the Quediini. Now we are able to see how much each of these groups resembles the other and how great the degree of difference is in each case.

The point I wish to show here is that there is much more to taxonomy than the segregation and naming of species. These should be used merely as tools to enable us to handle the groups while we combine and arrange them into a scheme which will show their interrelationships. How are we to know whether a particular group of specimens is a species unless we know in just what degree they differ from or resemble the numerous other groups we call species? We must know more than just the tail-end of the scheme of evolution if we are to be able to say that a group of individuals is a species, a subspecies, a genus, or some other category.

The study of classifications will not, of course, be a cure-all for our problems of speciation, of descent, or of relationship, but it will go a long way toward giving us an understanding of how groups relate to each other, of what rank should be assigned to each group, and of what the course of evolution of these groups has probably been.

It is more the attitude of mind which is important, and when new facts are brought to light which affect our established system, we must not only be prepared to accept them for what they are worth, but we must have a background of thought which will en-

able us to see how they affect our ideas. To many a taxonomist the idea that he has consistently misused a category such as a genus or a species, giving it a higher or a lower rank than is consistent with the facts, is something that he is utterly unable to understand. The standard that he uses is so firmly fixed in his mind as the true standard of that category (let us say of a species) that he cannot believe that any facts could upset the standard.

On the other hand we have a taxonomist who is used to thinking in terms of a more or less complete classification, where the categories indicate the degree of known relationship. If evidence is discovered that shows that his species are in reality only subspecies (or races), he is not so likely to object because the groups are still intact and usable but are simply changed slightly in the system and a further opportunity is opened for showing the development of the system.

This subject of classification is a very broad one. It has ramifications in many directions. I have touched on certain phases only, without intending to give these an exclusive claim to importance. But let me summarize some of the principles that should be basic in the study of taxonomy. First of all, we *must* consider *all* the available data. This means that we must use characters from whatever field of science we can; in the case of morphology, which is most important, we must aim to use all the structures on the insect, whether they are obscure or hard to examine or little known, and our only guide here shall be that comparative studies must show them to be of value for what we are trying to do. This principle, then, demands a complete knowledge of morphology and homology as basic to any study of systematics.

The second principle is this. Regardless of other considerations, we must use methods of study or procedures in working that will give the most complete and accurate results. We must not let our methods depend on the habits of the past. The important thing is not to follow any set procedure, but to treat every case on its merits and requirements and to employ every means possible to arrive at the complete truth. For example, if we find an important character on an insect that requires dissec-

tion of our specimens, we cannot neglect to dissect them if we are to be worthy of the name of scientist. Or if we should find that facts from genetics, ecology, development, or paleontology are significant, we must not fail to consider them adequately.

Our third basic step is to carry our work on to its logical conclusion, at least as far as taxonomy is concerned. If we merely describe species and genera and are not able to show exactly how they relate to other known species and genera, where they fit into the whole structure of evolution, how they add to our knowledge of the whole scheme of life, we will have missed our principal opportunity to make real contributions to science. We speak of the species that are "known to science," yet how many of these are really known in any sense beyond the publication of a name and description? Many are, of course, but not a very large percentage of the enormous numbers named. The placing of a species in a genus, and the genus in a family, without very careful consideration of the foundations of these groups, adds little to the general picture of relationships which we are attempting to set up.

This brings us to the fourth, and in some ways the most important, principle. We must make our results available for other scientists to see and understand. Endless series of new species and new genera not only do not aid the workers in other branches of science but actually serve to make taxonomy appear to them as meaningless and purposeless. I'm sure you will agree that this is the condition in which we find ourselves today, for many other biologists have no conception of the part which taxonomy can play in science and are inclined to look upon taxonomists merely as egotists trying to attach their own names as authors of new species. Taxonomy was once much more than that and can be again, but we will have to enlarge our horizons, raise many of our standards of thinking, and make our results available and useful to the rest of science.

ATRYTONE LOGAN EDWARDS

Another record for Sharon, Connecticut, is a pair of *Atrytone logan* Edwards caught July 21 and 22. These two specimens as well as the *Carterocephalus palaemon* race *mandan* were caught by the author and are now in the collection of The American Museum of Natural History, New York City.—LEONARD J. SANFORD.



SOME PARASITES AND HYPERPARASITES OF THE CECROPIA MOTH¹

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When parasitic insects are bred from a lepidopterous cocoon or chrysalis, it is too often concluded that these insects are parasites of the lepidopteron, without much thought of hyperparasitism. Thus any worker interested in the specific parasitic reactions of a particular group of insects is prone to regard with suspicion reports which simply state that a certain insect is a parasite of a certain moth or butterfly.

This study was undertaken in the hope of indicating some of the possibilities that may be obtained from one of the larger moth cocoons. The writer of course realizes that a study of this kind from a limited locality, in which only the end results are examined, is far from being complete. However, it is hoped that some of these results may be suggestive. Some of this work was done at the North Dakota State College.

So far as the writer could determine, the most thorough recent work on the parasitism of the cecropia moth was done by Marsh (1934). Parts of this investigation have been published (1936) and (1937).

The cecropia moth cocoons which were used in this study were all collected at Brooklyn, New York, by Mr. J. H. Cohen of 1532 Sterling Place. During the summer of 1937, some parasites bred by Mr. Cohen were examined, so he was really responsible for the writer's initial interest in the problem. Three lots of cocoons were received from Mr. Cohen: one lot collected November 11, 1937, one collected March 19, 1938, and the third lot December 15, 1938. The first group contained 113 cocoons, most of which were supposedly parasitized. Mr. Cohen stated that in

¹ The writer wishes to express sincere appreciation to the following men for assistance in determining some of the insects mentioned in this article: Mr. C. F. W. Muesebeck, Mr. A. B. Gahan, who determined the chalcidoids; Mr. R. A. Cushman, who determined the ichneumonid, and Mr. D. G. Hall, who determined the Diptera.

procuring this material he handled 228 cocoons and determined the parasitized insects by shaking the cocoons. The second lot, which were selected for parasitic Ichneumonidæ, contained only 20 selected cocoons. In obtaining these, 250 cocoons were examined. The third group consisted of 40 cocoons, most of which were parasitized.

In most instances, a parasitized cecropia cocoon is somewhat lighter in weight than a healthy one. Parasitized cecropia larvæ, after they spin a cocoon, will in many cases become hard and dry, and break into several parts. Thus, the cocoon will rattle if it is shaken. Actual dissection of cocoons indicated that one can depend upon the "shaking test" to a very high degree in distinguishing between parasitized and healthy cocoons.

In obtaining the following results, all the cecropia cocoons were opened, and the parasites examined. The parasitic larvæ and pupæ were then placed in watch glasses in the laboratory until they emerged as adults. Since these insects were kept in the laboratory at a fairly constant temperature, they presumably emerged earlier than they would have in nature.

It has been thought best to center this discussion about several of the insects which were primary parasites of the cecropia, and which also served as hosts for some other parasite.

Pseudogaurax anchora (Lw.) (Chloropidæ)

This insect was by far the most prevalent parasite of the cecropia cocoons examined. Out of 100 cocoons upon which accurate records were kept, this dipteron occurred in 54. The larvæ occurred within all parts of the dried tissues of the host. The number of parasites present varied from only a few in some cases to 81 in one cocoon. Many of the dipterous larvæ were dead when discovered, and many were themselves parasitized. Possibly because of laboratory conditions, and because of the heavy parasitism by a small chalcidoid, only one adult specimen was obtained from the first shipment of cecropia. Several adults, however, emerged from the second and third groups. It is interesting to note that Kaston and Jenks (1937) report this same species as a parasite of spider egg cases.

The chalcidoid parasitizing the larvæ of *Pseudogaurax anchora*

has been determined by Mr. Gahan as a new species of *Pleurotropis* (Eulophidæ). This insect is an internal parasite, and is difficult to discover until the host forms a puparium, or just before the puparium is formed. The puparia, although small, may easily be dissected without injuring the parasites to any great extent, by partially burying the puparia in household cement, and allowing this to dry. Dissecting needles may then be used to pull away the puparial skin. The number of parasites found within, or emerging from, a single puparium, varied from 2 to 10.

Achætoneura samia Web. (Tachinidæ)

This insect occurred occasionally, as a primary parasite, within all three lots of cocoons, and several adult specimens were reared. In addition, a single specimen of *Sarcophaga misera* var. *saracenoides* Ald. (Sarcophagidæ) emerged. A large number of dipterous puparia were found which varied somewhat in size and coloration. Since many of these did not emerge as adults, the writer could not determine to his entire satisfaction that these were all of the same species. It is thought probable, however, that most of these puparia were those of *Achætoneura samia*, since only a single specimen of any other large dipteran was obtained. But the possibility that other species might have been represented should not be overlooked. From the first lot of cocoons, only 19 out of 100 cocoons were parasitized, or showed signs of having been parasitized, by a large dipteran. The parasitized cecropia in some instances had formed a pupa within the cocoon before dying. In a few cases, the parasites had emerged from the host and formed puparia loose in the cocoon; in other cases, puparia were formed within the body of the host.

Several of the dipterous puparia were parasitized. Within one puparium, 22 chalcidoid pupæ were found, and several other dissected puparia yielded additional parasites. In addition, many of these insects emerged in the breeding bags. This parasite proved to be *Dimmockia incongruus* Ashm. (Eulophidæ). All these insects were in the pupal stage, and some of these pupæ were likewise parasitized. Within the pupal skin of some of these insects were the larvæ or pupæ of *Pleurotropis tarsalis* (Ashm.). Normal pupæ of *D. incongruus* were of a uniform glossy black

color, but the parasitized pupæ were brownish, and the pupal skin was broken in many cases. *Pleurotropis tarsalis* was thus in this instance a tertiary parasite.

Spilocryptus extrematus Cress. (Ichneumonidæ)

From the first lot of cecropia cocoons examined, only a single cocoon was parasitized by this ichneumonid. Within this one cocoon, however, there were 54 cocoons of this parasite, all of which were still in the larval stage when they were examined January 6. None of these ichneumonids was parasitized.

The second lot of cecropia, however, had been collected specifically for this parasite in a somewhat different region, and some of the cocoons had been opened in order to determine definitely the nature of parasitism. Thus, in the second lot, there were 12 cocoons, out of the 20 received, which were parasitized by *Spilocryptus extrematus* Cress. Two species of chalcidoid parasites were parasitic upon ichneumonids from 6 of these 12 parasitized cecropia cocoons. These insects were *Dibrachys cavus* (Walk.) (Pteromatidæ), and *Monodontomerus* sp., (F) (Callinomidæ).

The pteromalids were present within two of the cecropia cocoons, and at the time of dissection, March 31, these insects were in the pupal stage. Possibly because of the warm laboratory temperature, these insects emerged a few days later as adults. Females oviposited readily into living ichneumonid larvae.

Monodontomerus sp., was obtained from 4 of the parasitized cecropia cocoons. Presumably these insects were external parasites of *Spilocryptus extrematus*, and at the time of dissection, March 30, occurred in both the larval and pupal stages. The parasites were loose in the ichneumonid cocoon, and in most instances the shriveled-up larva of the host was still present.

In the laboratory, the females did not show particular interest in cocoons or naked larvæ of *Spilocryptus extrematus*, and no attempt was made to oviposit. When, however, a cecropia cocoon containing ichneumonid cocoons was placed with the females, several attempts were made to oviposit through the cecropia cocoon. One female also crawled into the cocoon and stayed several minutes. Whether or not oviposition occurred is not known.

It would seem, however, that in this case, the combination of the cecropia cocoon plus the ichneumonid cocoons, was a stronger stimulus to oviposition than the ichneumonid larvæ or cocoons alone.

It is thought probable that the females of *Monodontomerus* sp., since these insects possess a comparatively short ovipositor, crawl through the valve of the cecropia cocoon, and oviposit directly into the cocoon of their host. In all cases of parasitism examined, the callimomids were inside the host cocoon. Only a few of the total ichneumonid cocoons were parasitized.

MULTIPLE PARASITISM

In a few cases, cecropia cocoons contained several types of parasites. One cocoon was of particular interest. Within this cocoon were several cocoons of *Spilocryptus extrematus*, all insects of which were in the pupal stage. In addition there were several larvæ of *Pseudogaurax anchora*, and some large dipterous puparia. Within two of these dipterous puparia were pupæ of *Dimmockia incongruus*, and some of these in turn were parasitized by *Pleurotropis tarsalis*. This cecropia had, therefore, directly or indirectly, supported insects of 5 species. It is probable that under normal conditions most of these insects would have emerged as adults. But in this particular case, there was a hole in the cocoon, indicating that a bird had enjoyed a meal at the expense of the enclosed occupants. Consequently several of these insects were dead.

I believe this study emphasizes the fact that parasitic populations of a given host may vary considerably from locality to locality and even may vary in regions of the same locality. Marsh (1934), in a study of cecropia cocoons collected in the vicinity of Chicago, reared 9 species of parasitic insects. Of the 9 species reared by the writer, only three, *Dimmockia incongruus*, *Spilocryptus extrematus*, and *Pleurotropis tarsalis*, were identical with species obtained by Marsh. In the Chicago area, Marsh discovered that *Spilocryptus extrematus* was the principal primary parasite of the cecropia. In the present study, the principal primary parasite was *Pseudogaurax anchora*, and parasitism by *Spilocryptus extrematus* was extremely limited.

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COMPARISON OF SEROLOGIC AND TAXONOMIC RELATIONSHIPS OF DROSOPHILA SPECIES*

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INTRODUCTION

During the past two years studies have been made of extracts prepared from various species of *Drosophila* with the view of distinguishing the species through the use of serological procedures. Several different technics have been tried, and the reagents which were tested have been prepared in different ways. The results of these experiments have been published in several reports, to which reference will be made later. The purpose of this work is to compare the species relationships, as revealed by the serologic investigations of their antigens, with the relationships which are recognized on the basis of the more commonly accepted taxonomic criteria.

Although the different serological tests have yielded similar results, seldom have they offered exactly the same relations among the several species. It is impossible, at the present time, to state with certainty which technic reveals most nearly the real biochemical relationships among the species. Boyden (1936) has stated that no two technics are of equal worth; and Chester (1937), in his extensive review of plant serology, has been unable to conclude which of the many technics and modifications most nearly reveal the truth. This lack of agreement of the various tests and the consequent indecision regarding the relative value of serologic technics present a problem not greatly different from that of the taxonomist. The taxonomist is confronted with the difficulty of determining which characteristic or group of characteristics relates most truly the various species.

* The methods herein discussed were presented in demonstration at the Sixth Annual Meeting of the Genetics Society of America, Indianapolis, 1937. An abstract may be found in Records of the Genetics Society of America, No. 6, p. 146, 1937.

This article was taken from the author's Ph.D. Dissertation, The University of Texas, June, 1938.

Aside from the difficulty in appraising the systematic worth of any morphological characteristic, another problem of species inter-relations presents itself. A given characteristic which is thought to be of specific value may serve well to distinguish one species from a second, but may in turn be shared by a third species. This fact, no doubt, has contributed considerably to the confusion regarding our knowledge of evolution and inter-relations of species. In serological investigations of animals relationships the same feature has been noted by Irwin (1938), who found that each dove or pigeon species possessed cellular substances, determined by the agglutinin-absorption technic, which were not found in any of the other species. Also, he showed that some of the serological characteristics which distinguished one species from another could in turn be shared with still other species. Hence, difficulties of evaluating specific qualities are common to both the morphologic and immunologic procedures. In serologic tests, however, the reactive substances are biochemical elements of the body tissues of the animal. Through the application of technics which assay these fundamental chemical properties of the organism, we should be able ultimately to determine with a reasonable degree of exactitude the extent to which the protoplasm of one species is similar to that of others.

MATERIALS AND METHODS

In the serological tests that have been performed the relationships of about a dozen *Drosophila* species have been studied. Extensive data, however, have been accumulated only for the four species: *D. caribbea*, *D. melanogaster*, *D. mulleri*, and *D. virilis*. At least a dozen tests, representing several different procedures, have been performed on the antisera to each of these species. The taxonomic data used in this report were taken largely from Professor Sturtevant's work (1921). These data were supplemented by those of other authors (Metz, Moses, and Mason, 1923) and by some of my own observations. Recognizing our incapacity to appraise the relative specific worth of any morphological unit or serological reaction, I have assumed that all of the various immunological tests are of equal value, and that all of the fourteen taxonomic characters are of equal value.

The serological reactions which were employed in this comparison were as follows:

1. Complement-fixation reactions, using as antigens the saline extracts of dried flies, without any further extraction (Cumley and Haberman);

2. Precipitation reactions—ring tests, using the same antigens as in the preceding (Haberman and Cumley);

3. Complement-fixation reactions, using as antigens the saline extracts of the ether-insoluble fractions of dried flies (Cumley, 1939);

4. Optimal antigen-antibody ratio reactions, using the same antigens as in the tests immediately above (Cumley, 1938);

5. Precipitin absorptions, using the same antigens as in the preceding (Cumley, 1939, a).

The systematic characteristics employed in this comparison were as follows:

1. Costal index: Length of 2nd section of costal vein/Length of 3rd section of costal vein;

2. Fourth-vein index: Length of 4th (distal) section of 4th vein/Length of 3rd section of 4th vein;

3. 4c index: Length of 3rd section of costal vein/Length of 3rd section of 4th vein;

4. 5x index: Length of 3rd (distal) section of 5th vein/Length of posterior vein;

5. Number of branches of arista;

6. Approximate width of the "front"/width of the head;

7. Size of 2nd orbital bristle/Size of the other two;

8. Size of the 1st oral bristle/Size of the 2nd;

9. Greatest width of the cheeks/Greatest diameter of the eyes;

10. Number of rows of acrostichal hairs;

11. Number of filaments on eggs;

12. Body length;

13. Wing length;

14. Number and type of chromosomes.

In order to rank the species serologically, each serologic test was considered separately, and the species were arranged in the order of the extent of reactivity of their antigens to the particular antiserum in question. This procedure was repeated for each

of the several tests. Since all the tests of a given antiserum did not rank the species in the same order, the result was that any one species would sometimes assume second, and sometimes third or fourth place. From data taken in this way from the various tests, it was possible to observe the number of times a particular species assumed each of the four serological ranks made possible by a consideration of only four species. The percentage ranks were calculated from these observations and are shown in Table 1.

TABLE 1
SEROLOGIC RANKING

Species for comparison	Percentage ranks			
	1	2	3	4
Species in question: <i>Drosophila melanogaster</i>				
<i>D. melanogaster</i>	100.0	0	0	0
<i>D. caribbea</i>	0	96.5	3.5	0
<i>D. mulleri</i>	0	3.5	64.3	32.2
<i>D. virilis</i>	0	0	32.2	67.8
Species in question: <i>Drosophila caribbea</i>				
<i>D. caribbea</i>	100.0	0	0	0
<i>D. melanogaster</i>	0	71.1	13.5	15.4
<i>D. mulleri</i>	0	11.5	57.8	30.7
<i>D. virilis</i>	0	17.4	28.7	53.9
Species in question: <i>Drosophila mulleri</i>				
<i>D. mulleri</i>	100.0	0	0	0
<i>D. virilis</i>	0	88.5	11.5	0
<i>D. caribbea</i>	0	7.7	69.3	23.0
<i>D. melanogaster</i>	0	3.8	19.2	77.0
Species in question: <i>Drosophila virilis</i>				
<i>D. virilis</i>	100.0	0	0	0
<i>D. mulleri</i>	0	82.2	3.6	14.2
<i>D. caribbea</i>	0	17.8	50.0	32.2
<i>D. melanogaster</i>	0	0	46.4	53.6

In this table one may observe that, with reference to *D. melanogaster*, the four *Drosophila* species are ranked as follows: *melanogaster*, 1st place in 100 per cent of the tests; *caribbea*, 2nd place in 96.5 per cent, and 3rd place in 3.5 per cent of the tests; *mulleri*,

2nd place in 3.5 per cent, 3rd place in 64.3 per cent, and 4th place in 32.2 per cent of the tests; *virilis*, 3rd place in 32.2 per cent and 4th place in 67.8 per cent of the tests. The same type of information is to be seen in the remainder of the table. That is to say, all four of the species are ranked in their respective relations to a given species.

The taxonomic ranking has been accomplished in much the same way, except that instead of considering serological tests, the individual morphological units have been applied. The species are then ranked in the order of their relationship in terms of a given systematic criterion. As in the preceding rankings, the percentage ranks of the various species with reference to a given species have then been calculated. These percentage ranks have been presented in Table 2. In this table one may see that the

TABLE 2
TAXONOMIC RANKING

Species for comparison	Percentage ranks			
	1	2	3	4
Species in question: <i>Drosophila melanogaster</i>				
<i>D. melanogaster</i>	100.0	0	0	0
<i>D. caribbea</i>	0	77.0	23.0	0
<i>D. mulleri</i>	0	7.6	42.4	50.0
<i>D. virilis</i>	0	15.4	34.6	50.0
Species in question: <i>Drosophila caribbea</i>				
<i>D. caribbea</i>	100.0	0	0	0
<i>D. melanogaster</i>	0	84.8	11.5	3.7
<i>D. mulleri</i>	0	7.6	46.2	46.2
<i>D. virilis</i>	0	7.6	42.3	50.1
Species in question: <i>Drosophila mulleri</i>				
<i>D. mulleri</i>	100.0	0	0	0
<i>D. virilis</i>	0	69.3	7.6	23.1
<i>D. melanogaster</i>	0	11.5	53.8	37.7
<i>D. caribbea</i>	0	19.2	38.6	42.2
Species in question: <i>Drosophila virilis</i>				
<i>D. virilis</i>	100.0	0	0	0
<i>D. mulleri</i>	0	77.3	4.5	18.2
<i>D. melanogaster</i>	0	9.1	59.1	31.8
<i>D. caribbea</i>	0	13.6	36.4	50.0

various *Drosophila* species are related to *D. melanogaster* as follows: *melanogaster*, 1st place in 100 per cent of the characters; *caribbae*, 2nd place in 77.0 per cent and 3rd place in 23.0 per cent of the characters; *mulleri*, 2nd place in 7.6 per cent, 3rd place in 42.4 per cent, and 4th place in 50.0 per cent of the characters; and *virilis*, 2nd place in 15.4 per cent, 3rd place in 34.6 per cent, and 4th place in 50.0 per cent of the taxonomic characters. Similarly, all four of the species are ranked taxonomically in their relations to a given species.

RESULTS

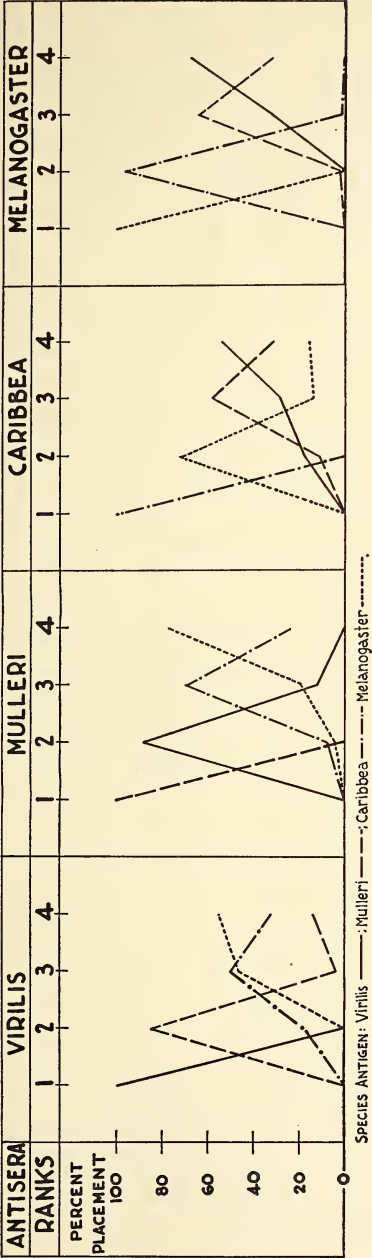
Figure 1 has been prepared in order that a more graphic view may be obtained of the comparison of the serologic and taxonomic rankings. From a perusal of this figure and the data of Tables 1 and 2 several facts become apparent:

1. The serological and taxonomic technics have always presented the same species for second rank.

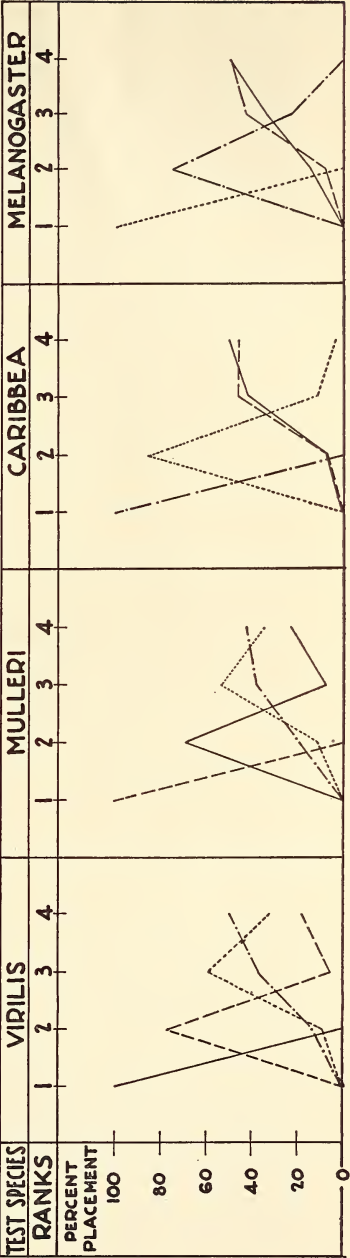
2. With reference to ranks three and four, the taxonomic and serologic methods have given essentially the same results in two of the comparisons (*D. melanogaster* and *D. caribbae*), and have failed to correspond, apparently, in the other two comparisons. In the two cases where the results failed to coincide, however, there is some doubt as to the real ranking on the basis of taxonomic data. That is to say, when the species were ranked taxonomically in relation to *D. virilis*, the species *caribbae* assumes fourth rank in 50.0 per cent of the characteristics, whereas *melanogaster* ranks fourth in only 31.8 per cent of the tests. By virtue of these figures alone, *caribbae* obviously would receive fourth rank. However, *caribbae* also ranks second in 13.6 per cent of the systematic features, whereas *melanogaster* ranks second in only 9.1 per cent. Therefore, it is impossible to determine offhand which of the two species should be considered as ranking third place. The same situation exists when the species are given morphological ranks, with reference to *D. mulleri*.

In general, then, we may conclude that the taxonomic and serologic methods agree definitely to the extent of the second rank, and when they disagree as to the third and fourth ranks, the taxonomic method has not clearly indicated which order of relationship is correct.

FIGURE 1
SEROLOGIC RANKING OF DROSOPHILA SPECIES



TAXONOMIC RANKING OF DROSOPHILA SPECIES



3. The results of the serologic ranking apparently are more specific than are those of the taxonomic ranking. This fact is indicated by several features of Figure 1 and Tables 1 and 2. First, a species which ranks third serologically always is represented by a sharply-peaked curve. Not only is that not the case with the taxonomic ranking, but there is always some doubt as to which species really ranks third. This fact is readily apparent since all of the curves representing the third and fourth places, taxonomically, cross each other or coincide in at least three points; whereas in the curves representing the serologic ranks, only twice do the 3rd and 4th rank curves coincide more than once. Furthermore, in none of the taxonomic rankings, as observed in Table 2, is it possible to determine which species ranks third and which fourth; whereas in the serologic data of Table 1, in only one ranking (*caribbea*) is this the case. Second, in two of the serological rankings those species which rank fourth never ranked second in any of the tests. In the case of the taxonomic ranking, all the species that ranked fourth on the basis of some morphological unit, ranked second on the basis of some other. Third, those species which are ranked fourth serologically are so ranked by virtue of from 53.6 per cent to 77.0 per cent of the tests indicating this rank. Those species ranked fourth taxonomically are so ranked by virtue of 42.2 per cent to 50.1 per cent of their characteristics. Similar figures may be observed for the second and third ranks.

4. The two subgroups designated by Sturtevant (1921) as subgroup 1 and subgroup 2 of Group F have been definitely indicated by the serologic methods, as well as by the taxonomic studies. Sturtevant's subgroup 1 includes the yellowish or reddish species of which *D. melanogaster* and *D. caribbea* are members. Subgroup 2 includes the blackish or grayish species of which *D. virilis* and *D. mulleri* are members. In the serologic ranking as well as in the morphologic ranking, *D. virilis* and *D. mulleri* always rank close together, and *D. caribbea* and *D. melanogaster* always rank close together. If one assumes that these two subgroups arose from a common stock and that the species of each subgroup diverged much later, then this is more or less the relation one would expect to find.

CONCLUSIONS

Serologic technics recently have been employed by several investigators in relating or ranking species of molluscs (Makino, 1934), helminths (Eisenbrandt, 1936), amphibia (Boyden and Noble, 1933), moths (Martin and Cotner, 1934), and other animal species. Problems of hybrids, likewise, have been attacked by these biochemical methods (Irwin, 1938; Irwin and Cole, 1936 a & b; Irwin, Cole and Gordon, 1936). In general the results have been sufficiently encouraging to warrant the application of serologic technics to an analysis of *Drosophila* species. The present paper and those which have preceded serve to indicate the results which may be expected from such procedure. Obviously, the work has only begun, and several refinements are necessary. It is believed, however, that these methods eventually will provide valuable data relative to problems of speciation and phylogeny. Furthermore, the recent work of Levit, Ginsburg, Kalinin, & Feinberg (1936) suggests the possibility of applying immunologic technics to the study of the expression of individual chromosomes or even genes. To what extent the method may be utilized remains at present a matter of conjecture.

These comparisons have demonstrated that on the basis of morphology, species cannot always be ranked to the third and fourth places, but with the serologic methods this can be accomplished. In cases where morphological differences are insignificant or absent, the serologic technics may provide adequate means of determining species relationships.

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NEW PERUVIAN MEMBRACIDÆ (HOMOPTERA)

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A large collection of Membracidæ recently received from Peru contains several new species which are here described and figured as follows:

1. *Lycoderes luteus* sp. nov. (Fig. 1)

Large, yellow, coarsely punctate, not pubescent; head quadrate, subfoliaceous; pronotum extended into flattened porrect horn; posterior process flattened, tectiform, separated very little from anterior portion of pronotum and reaching to the internal angles of the tegmina; tegmina hyaline with basal and anal areas coriaceous; legs yellow and foliaceous; undersurface of body yellow.

TECHNICAL DESCRIPTION:

Head quadrate, broader than high, roughly sculptured, finely punctate; base feebly arcuate and sinuate; eyes flattened, brown; ocelli small, inconspicuous, much farther from each other than from the eyes and situated close to the upper margin of the head, far above a line drawn through centers of eyes; inferior margins of genæ lobate, foliaceous and sinuate; clypeus broad, subovate, not extending below inferior margins of genæ, tip truncate.

Pronotum flattened laterally, yellow tinged with brown, coarsely punctate, not pubescent, bearing a porrect frontal horn and a strong posterior process with very little constriction between the two; pronotal horn porrect, subtriangular, laterally flattened, tip blunt with a weak lateral extension on each side; posterior process heavy, laterally flattened, coarsely punctate but not laterally carinate, sharply tectiform, median carina strongly percurrent, tip blunt and extending just to the internal angles of the tegmina; humeral angles weak and rounded; scutellum well exposed on each side, below a weak inferior constriction between the frontal horn and the posterior process.

Tegmina broad, entirely exposed, hyaline; base broadly brown, coriaceous and punctate; anal margin narrowly brown, translucent and punctate; five irregular apical cells; one discoidal cell; apex rounded; anal margin truncate; no apical limbus.

Legs yellow and foliaceous; all tarsi about equal in length. Sides of mesonotum and metanotum extended into pointed teeth. Under-surface of body yellow; abdomen greenish.

Length from front of head to tips of tegmina 6.2 mm.; width between humeral angles 2 mm.

Type: Female.

Type locality: Guaybamba, Amazonas, Peru.

Described from a single specimen collected in August 1936. Type in author's collection.

2. *Stylocentrus rubrinigris* sp. nov. (Fig. 2)

Shining black with the tegmina and abdomen strongly marked with red; base of head strongly bituberculate; pronotum gibbous with a pair of slender, curved frontal horns and a slender, arched posterior horn, all three arising from a very short stalk; no posterior process; scutellum entirely exposed; tegmina hyaline with heavy black veins and with membrane strongly tinged with red; legs and undersurface of body rufous; abdomen red.

TECHNICAL DESCRIPTION:

Head triangular, black with white pubescence, roughly sculptured, finely punctate; base arcuate and sinuate and bearing two prominent tubercles; eyes large, globular, glassy; ocelli small, amber-colored, situated on rounded elevations more than twice as far from each other as from the eyes and located near the base of the head far above a line drawn through centers of eyes; inferior margins of genæ straight and sloping; clypeus sharply pointed, extending for one-third its length below inferior margins of genæ.

Pronotum convex and gibbous, black, finely punctate, and bearing a linear white tomentose patch below the horns; a very short porrect stalk gives rise to a pair of long, slender, recurved frontal horns and a slender, tricarinate posterior horn which arches high above the body and then curves downward, well above the abdomen and reaching almost to the internal angles of the tegmina; scutellum entirely exposed; triangular, tip sharp; humeral angles weak and rounded; inferior margin of pronotum projected downward in a tooth.

Tegmina entirely exposed, long, narrow, hyaline; base and entire clavus coriaceous and punctate; membranes of basal half bright red; veins heavy and black; five irregular apical and two irregular discoidal cells; anal margin truncate; no apical limbus.

Sides of thorax reddish-black with white pubescence; legs simple, reddish-black, hind tarsi longest; abdomen red.

Length from front of head to tips of tegmina 7.2 mm.; width between tips of frontal spines 5 mm.

Type: Male.

Type locality: Callanga, Peru.

Described from a single specimen in the author's collection. This species is close to *S. championi* Fowler but is much larger and differs particularly in the structure of the pronotal spines.

3. *Alchisme laticornis* sp. nov. (Fig. 3)

Heavy bodied, reddish-brown mottled with black, coarsely punctate, sparingly pubescent; humeral angles produced into long, sharp horns; median pronotal horn broad, flat and ridged; posterior process heavy, tectiform and nearly straight; tegmina subhyaline, bronze, with very broad veins; legs and undersurface of body reddish-brown; hind tarsi very short.

TECHNICAL DESCRIPTION:

Head subquadrate, twice as broad as high, roughly sculptured; base arcuate and sinuate; eyes large, gray, globular; ocelli large, prominent, glassy, much nearer to each other than to the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ straight and swollen; clypeus reflexed, extending for half its length below inferior margins of genæ, tip blunt.

Pronotum convex, rounded, reddish-brown with a transverse black band extending across the top of the metopidium and covering the dorsal surfaces of the humeral spines, coarsely punctate, sparingly pubescent, produced at the shoulders into long spines, above into a broad median horn and behind into a heavy posterior process; metopidium sloping, broader than high; median carina strongly percurrent; humeral angles extended into heavy, flattened, sharp spines extending outward and forward; median pronotal horn erect, laterally flattened, irregularly ridged on both sides, higher than its breadth at base, anterior margin nearly straight, posterior margin rounded, tip blunt; posterior process heavy, nearly straight, tectiform, tip sharp and extending a little beyond the internal angles of the tegmina.

Tegmina subhyaline, smoky-brown, entirely exposed; basal and costal areas coriaceous, brown and punctate; veins very broad; five apical and three discoidal cells; apical limbus narrow. Hind wings with four apical cells.

Legs reddish-brown, stout; femora cylindrical; hind tibiæ flattened and spatulate at distal end; hind tarsi very short.

Length from front of head to tips of tegmina 8.2 mm.; width between tips of humeral spines 4 mm.

Type: Male.

Type locality: Pumamarca, Peru.

Described from a single specimen in the author's collection.

4. *Alchisme pinguicornis* sp. nov. (Fig. 4)

Small, uniformly dark brown, punctate, pubescent; humeral angles cylindrical, blunt, extending outward and slightly forward; dorsal crest erect, thick, heavy, rounded, tricarinate on each side with the posterior ridge extending to the inferior lateral margin of the pronotum; posterior process long, slender,

acute, reaching beyond the internal angles of the tegmina; tegmina dark brown with strongly pilose veins; legs and undersurface of body brown.

This species is near the preceding but is much smaller and differs particularly in the structure and sculpturing of the head and pronotal process. It is also apparently near *A. turrita* Germar but is not identical.

TECHNICAL DESCRIPTION:

Head subquadrate, three times as broad as high, black, finely punctate, sparingly pilose; base arcuate and feebly sinuate; eyes large, black, ovate; ocelli small, inconspicuous, amber-colored, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ regularly curved; clypeus short, rounded, extending only a little below inferior margins of genæ and continuing the rounded inferior outline of the face made by these margins.

Pronotum dark brown, coarsely punctate, sparingly pubescent; metopidium sloping; broader than high; median carina strongly percurrent; humeral angles extended into heavy, subconical, blunt horns projecting outward and slightly forward; median dorsal crest thick, heavy, arising from just behind the humeral angles, only slightly flattened laterally, about as high as its width at base, tip broadly rounded, three ridges on each side, the posterior ridge very heavy and reaching to the inferior lateral margin of the pronotum; posterior process long, slender, tectiform, nearly straight, tip acute and reaching to a point about half-way between internal angles and tips of tegmina.

Tegmina entirely exposed, long, narrow, brown; basal and costal areas coriaceous and punctate; veins strongly pilose; five apical and three discoidal cells; apical limbus broad.

Undersurface of body dark brown; legs simple, slender, very dark brown; hind tibiæ spatulate; hind tarsi much shorter than the others.

Length from front of head to tips of tegmina 6.8 mm.; width between tips of humeral spines 3.5 mm.

Type: Male.

Type locality: Santo Domingo, Peru.

Described from a single specimen collected in November 1937 by Mr. Felix Woytkowski. Type in author's collection.

5. *Alchisme spinosa* sp. nov. (Fig. 5)

Large, pale greenish-yellow, coarsely punctate, not pubescent; humeral angles long, slender, projecting outward, upward and forward; dorsal spine long, sharp, slightly curved; posterior process tectiform, straight, sharp, just reaching tips of tegmina; tegmina hyaline, free; undersurface yellowish-green.

TECHNICAL DESCRIPTION:

Head subovate, twice as broad as high, yellow, smooth; base high and strongly bisinuate; eyes large, ovate, brown; ocelli large, conspicuous, yellow, equidistant from each other and from the eyes and situated on a line drawn through centers of eyes; inferior margins of genæ sinuate and sloping; clypeus extending for half its length below inferior margins of genæ.

Pronotum greenish-yellow, coarsely punctate, not pubescent, margins smooth and strongly carinate; metopidium triangular, higher than broad; median carina strongly pereurrent; humeral angles extended into long spine-like processes, longer than the width of the metopidium, extending strongly outward and slightly upward and forward, base impinging on the eyes, somewhat flattened dorso-ventrally, tips rounded; dorsal spine long, acute, arising from behind humeral angles, laterally flattened, slightly recurved, margins ridged; posterior process long, slender, tectiform, straight, tip sharp and just reaching tips of tegmina.

Tegmina hyaline, entirely free; basal and costal areas narrowly coriaceous and punctate; veins strong; five apical cells; discoidal cells small and variable in number; apical limbus broad.

Sides of thorax and undersurface of body yellow; legs yellow, simple; hind tarsi much shorter than the others.

Length from front of head to tips of tegmina 12 mm.; width between tips of humeral spines 9 mm.

Type: Female.

Type locality: Santo Domingo, Peru.

Described from two females collected at the type locality in November 1937 by Mr. Felix Woytkowski. Type and paratype in author's collection.

6. *Paragargara nigra* sp. nov. (Fig. 6)

Small, black, finely punctate, sparingly pubescent; anterior pronotum strongly convex; median carina very sharp; no anterior processes; posterior process sharply set off by a deep indentation; tegmina hyaline with inconspicuous veins; legs simple.

TECHNICAL DESCRIPTION:

Head subfoliaceous, smooth, black, finely punctate, not pubescent, vertical; base arcuate and weakly sinuate; eyes large, globular, white; ocelli small, inconspicuous, glassy, twice as far from each other as from the eyes and situated high up near the base of the head far above a line drawn through centers of eyes; inferior margins of genæ short, sinuate and sloping; clypeus very broad, flat, extending for two-thirds its length below inferior margins of genæ, tip truncate.

Pronotum strongly convex, gibbous, dull black, very finely punctate, sparingly pubescent, slightly carinate on each side; metopidium vertical, broader than high; median carina sharply pereurrent; humeral angles heavy, triangular, blunt; no anterior horns or processes; posterior process arcuate,

carinate, short, separated from the anterior pronotum by a deep depression which gives it an up-turned appearance, tip sharp, depressed and extending just to the internal angles of the tegmina.

Tegmina broad, hyaline, entirely exposed; base broadly black, coriaceous and punctate; veins indistinct; five apical and two discoidal cells; apical limbus very broad.

Sides of thorax and undersurface of body black; legs simple, ferruginous; all tarsi about equal in length.

Length from front of head to tips of tegmina 3.8 mm.; width between tips of humeral angles 1.7 mm.

Type: Female.

Type locality: Leonpampa, Peru.

Described from two specimens, a male and a female, the female from the type locality and the male from Marcapata, Peru. The male agrees with the female in all respects except that it is slightly smaller. Type and allotype in author's collection.

7. *Aconophora erecta* sp. nov. (Fig. 7)

Large, ferruginous, punctate, pubescent; anterior horn long, porrect, laterally flattened, tip recurved; posterior process heavy, decurved, reaching almost to tips of tegmina; tegmina fuscous-hyaline, entirely exposed; sides of thorax ferruginous; legs ferruginous, heavy, femora cylindrical, tibiæ triquerate; tarsi equal.

TECHNICAL DESCRIPTION:

Head triangular, punctate, pubescent; base arcuate and sinuate; eyes globular, black; ocelli large, conspicuous, brown, equidistant from each other and from the eyes and situated somewhat above a line drawn through centers of eyes; inferior margins of genæ sloping and strongly sinuate; clypeus broad, extending for half its length below inferior margins of genæ, tip pointed and hirsute.

Pronotum uniformly ferruginous, finely punctate, pubescent; metopidium projecting forward, triangular, broader than high; median carina percurrent; humeral angles heavy, rounded, blunt; anterior pronotal horn slender, laterally flattened, edges subfoliaceous, extending strongly upward and slightly forward, as long as the distance from its base to the humeral angles, tip broadly rounded, slightly recurved; posterior process heavy, convex, not carinate, tip sharp, depressed, and reaching almost to the tips of the tegmina.

Tegmina entirely free, fuscous-hyaline; base coriaceous, brown and punctate; basal area slightly pilose; tip pointed; veins strong; five apical and two discoidal cells; apical limbus broad.

Sides of thorax, undersurface of body and abdomen uniformly ferruginous; legs heavy, ferruginous; femora cylindrical; tibiæ triquerate and spined; all tarsi equal in length.

Length from front of head to tips of tegmina 6.3 mm.; width between tips of humeral angles 3.2 mm.

Type: Male.

Type locality: Napo River, Peru.

Described from a single specimen collected in June 1920. Type in author's collection.

8. *Aconophora brunnea* sp. nov. (Fig. 8)

Small, brown, punctate, pubescent; anterior horn thick, heavy, curving forward; posterior process stout, reaching to a point half-way between internal angles and tips of tegmina; tegmina entirely exposed, hyaline with brown markings; legs and under-surface of body brown.

TECHNICAL DESCRIPTION:

Head triangular, dark brown, punctate, pubescent; base arcuate and feebly sinuate; eyes ovate, glassy; ocelli small, inconspicuous, amber-colored, equidistant from each other and from the eyes and situated a little above a line drawn through centers of eyes; inferior margins of genæ sloping and sinuate; clypeus broad, extending for half its length below inferior margins of genæ.

Pronotum light brown, finely punctate, densely pubescent; metopidium extending forward, subtriangular, broader than high; median carina percurrent; humeral angles weak, rounded, blunt; anterior pronotal process heavy, stout, as long as the distance from its base to the humeral angles, flattened laterally, extending upward and forward and curving distinctly forward over the head and metopidium, tip broadly rounded; posterior process heavy, weakly tectiform, tip acute and reaching half-way between internal angles and tips of tegmina.

Tegmina narrow, entirely free, hyaline with a brown transverse band across the center, a brown spot half-way between this band and the base, and the apex tinged with brown; base narrowly coriaceous and punctate; veins strong and brown; five apical and two discoidal cells; apical limbus broad.

Sides of thorax, undersurface of body, abdomen and legs all uniformly brown. Legs stout; femora cylindrical; tibiæ triquerate and pilose; all tarsi about equal in length.

Length from front of head to tips of tegmina 5 mm.; width between humeral angles 2.7 mm.

Type: Female.

Type locality: Celendin, Peru.

Described from seven females and four males, three females collected at the type locality in May 1936, all of the others collected at Limon, Peru in June of the same year. Type, allotype and all paratypes in author's collection.

9. *Sundarion nigromacula* sp. nov. (Fig. 9)

Large, dull brown, coarsely punctate, not pubescent, with a large black spot on each side of the inferior margin of the pro-

notum just behind the middle; suprahumeral short, sharp, extending directly outward; posterior process slender, tectiform, reaching half-way between internal angles and tips of tegmina; tegmina free, smoky hyaline; sides of thorax and undersurface of body brown; legs simple, brown, hind tarsi longest. Near *S. brunniventris* Fairmaire but smaller and with very differently shaped suprahumeral.

TECHNICAL DESCRIPTION:

Head subtriangular, rough, brown with coarse black punctures and a black spot on each side of upper margin; not pubescent; base regularly arcuate; eyes large, ovate, glassy; ocelli conspicuous, a little nearer to each other than to the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ strongly sloping and weakly sinuate; clypeus feebly trilobed, extending for half its length below inferior margins of genæ, tip broadly rounded and weakly pilose.

Pronotum dark brown, coarsely punctate, not pubescent, convex in front; metopidium vertical, broader than high; median carina percurrent; humeral angles weak, triangular, acute; suprahumeral horns short, triquerate, not half as long as the distance between their bases, tips very sharp and black; dorsum roundly sloping; sides of pronotum weakly impressed near margin behind humeral angles; posterior process slender, tectiform decurved, tip acute and reaching to a point half-way between internal angles and tips of tegmina.

Tegmina entirely exposed, smoky hyaline; base narrowly brown, coriaceous and punctate; veins strong; five apical cells, median apical cell truncate at base; one elongate discoidal cell; apical limb broad.

Sides of thorax light brown; undersurface of body brown; legs simple, brown; hind tarsi longest.

Length from front of head to tips of tegmina 8 mm.; width between tips of suprahumeral 5.3 mm.

Type: Female.

Type locality: Tingo-Maria, Peru.

Described from a single specimen taken in September 1937 by Mr. Woytkowski. Type in author's collection.

10. *Ceresa luteimaculata* sp. nov. (Fig. 10)

Small, brown with yellow markings, punctate, pubescent; pronotum convex, strongly impressed above lateral margins; suprahumeral short, sharp extending directly outward; posterior process long, acute, decurved, reaching beyond internal angles of tegmina; sides of pronotum and tip of posterior process marked with bright golden yellow; abdomen black; legs ferruginous.

TECHNICAL DESCRIPTION:

Head subtriangular, wider than high, roughly sculptured, shining, brown mottled with black; base feebly arcuate; eyes large, globular, black; ocelli large, prominent, brown, much nearer to each other than to the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ sinuate and sloping; clypeus extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum brown, gibbous, coarsely punctate, sparingly pubescent; metopidium vertical, subquadrate, a little wider than high; median carina strongly percurrent; humeral angles heavy, triangular, blunt, extending outward slightly farther than the eyes; suprahumeral horns short, conical, blunt, no longer than half the distance between their bases, extending directly outward; a broad yellow band extending from base of suprahumeral to the lateral margins of the pronotum; sides of pronotum impressed and black; posterior process slender, subconical, not ridged, tip sharp, bright yellow, somewhat depressed and reaching to a point about half-way between internal angles and tips of tegmina.

Tegmina entirely free, hyaline; base narrowly yellow, coriaceous and punctate; veins heavy and curved; five apical and two elongate discoidal cells; apical limbus broad.

Sides of thorax brown and pubescent; legs uniformly ferruginous, simple, pilose; abdomen black.

Length from front of head to tips of tegmina 6 mm.; width between tips of suprahumeral 2.7 mm.

Type: Female.

Type locality: Shishmay, Peru.

Described from a single specimen collected in September 1937 by Mr. Felix Woytkowski. Type in author's collection.

11. *Ceresa grisescens* sp. nov. (Fig. 11)

Greenish with dark grizzly markings, coarsely punctate, sparingly pubescent; suprahumeral robust, extending directly outward, distinctly depressed at tips; sides of pronotum deeply impressed above lateral margins; posterior process heavy, strongly depressed, reaching to a point half-way between internal angles and tips of tegmina; tegmina hyaline with tips clouded; sides of thorax greenish; undersurface griseus; hind femora strongly marked with black.

TECHNICAL DESCRIPTION:

Head subtriangular, lightly punctate, green with strong black longitudinal striæ; base regularly arcuate; eyes globular, greenish; ocelli large, amber-colored, conspicuous, equidistant from each other and from the eyes and situated a little below a line drawn through centers of eyes; inferior mar-

gins of genæ strongly sloping and weakly sinuate; clypeus long, greenish with black stripe on each side, extending for more than half its length below inferior margins of genæ, tip blunt and densely pilose.

Pronotum convex, greenish with strong black scattered punctures which give a grizzly appearance; metopidium sloping, broader than high; median carina percurrent; humeral angles strong, triangular, blunt; suprahumeral horns robust, subconical, as long as half the distance between their bases, extending directly outward, tips blunt and strongly depressed; sides of pronotum strongly semicircularly impressed above lateral margins; dorsum regularly arcuate; posterior process heavy, subconical, distinctly curving downward, tip sharp and reaching a point half-way between internal angles and tips of tegmina.

Tegmina entirely free, hyaline; base narrowly coriaceous and punctate; apical and anal areas marked with brown; veins strong and curved; typically five apical and two discoidal cells but with the costal apical cells inclined to be subdivided; apical limbus broad.

Sides of thorax greenish, abdominal segments black edged with white; legs simple, hind femora strongly marked with black; hind tarsi longest.

Length from front of head to tips of tegmina 8 mm.; width between tips of suprahumeral 4.2 mm.

Type: Male.

Type locality: Limon, Peru.

Described from two males and one female all taken at the type locality by Mr. Woytkowski in June 1936. Type, allotype and paratype in author's collection. The female is a little larger and less griseus than the male.

12. *Stictolobus nitidus* sp. nov. (Fig. 12)

Brilliant shining reddish-brown with a golden spot in the middle of the dorsum; pronotum convex anteriorly and tectiform posteriorly; no suprahumeral; posterior process straight, reaching just beyond internal angles of tegmina; tegmina smoky-hyaline clouded with shining brown; undersurface and legs bright shining brown.

TECHNICAL DESCRIPTION:

Head subquadrate, twice as broad as high, smooth, shining, not punctate nor pubescent; base lightly arcuate and sinuate; eyes large, globular, glassy; ocelli conspicuous, amber-colored, about equidistant from each other and from the eyes and situated on a line drawn through centers of eyes; inferior margins of genæ sloping and sinuate; clypeus broad, not extending below lateral margins of genæ and continuing the inferior outline of the face made by those margins, tip truncate and pilose.

Pronotum bright shining reddish-brown with a golden mark in the center of the dorsum, weakly punctate, not pubescent; metapidium sloping, much broader than high; median carina almost obsolete over metapidium but

sharp on posterior process; humeral angles weak and rounded; sides of pronotum strongly impressed behind humeral angles; posterior process straight, tectiform, tip acute and reaching just beyond internal angles of the tegmina.

Tegmina entirely free, smoky-hyaline; base, central area and tip marked with shining brown; veins heavy and much curved; five apical and two discoidal cells; median apical cell petiolate; apical limbus broad.

Sides of thorax, undersurface of body and abdomen bright reddish-brown; legs simple, shining brown; hind femora strongly marked with black; hind tarsi longest.

Length from front of head to tips of tegmina 7.2 mm.; width between humeral angles 3 mm.

Type: Female.

Type locality: Limon, Peru.

Described from a single specimen collected in June 1936. Type in author's collection.

13. *Stictolobus marginatus* sp. nov. (Fig. 13)

Shining jet-black with a bright yellow stripe on the inferior lateral margins of the pronotum, coarsely punctate, sparingly pubescent; pronotum convex anteriorly and rounded posteriorly; no suprahumeral angles; sides of pronotum deeply impressed above lateral margins; posterior process subcylindrical, depressed, reaching to a point about half-way between internal angles and tips of tegmina; tegmina entirely free, subhyaline; undersurface of body black; legs slender, ferruginous; hind tarsi very much longer than the others.

TECHNICAL DESCRIPTION:

Head subquadrate, black, broader than high, roughly sculptured, shining, not punctate nor pubescent; base weakly arcuate and sinuate; eyes ovate and gray; ocelli large, amber-colored, nearer to each other than to the eyes and situated on a line drawn through centers of eyes; inferior margins of genæ sloping; clypeus extending for half its length below inferior margins of genæ, tip pointed and pilose.

Pronotum shining black with a bright yellow stripe on lateral margins, coarsely punctate, sparingly pilose with long bristly hairs; metopidium sloping, wider than high; median carina very faintly percurrent; humeral angles heavy and rounded, edged with yellow; no suprahumeral horns; sides of pronotum deeply impressed in a semicircle above lateral margins; posterior process swollen at base, then suddenly narrowed and extending to a point about half-way between internal angles and tips of tegmina, a yellow band just before the tip.

Tegmina entirely exposed, cloudy hyaline; base narrowly coriaceous, brown and punctate; veins weak; five apical and three discoidal cells; apical limbus broad and wrinkled.

Sides of thorax dark brown; abdomen black; legs simple, slender, ferruginous, tibiae margined with yellow; hind tarsi very long.

Length from front of head to tips of tegmina 6 mm.; width between tips of humeral angles 2.4 mm.

Type: Female.

Type locality: San Martin, Peru.

Description from a single female collected by Mr. Woytkowski in August 1936. Type in author's collection.

14. *Amastris peruviana* sp. nov. (Fig. 14)

Large, dull green, punctate, pubescent; pronotum roundly arcuate, laterally compressed, highest behind humeral angles; metopidium nearly vertical; posterior process triangular as seen from the side, almost reaching the tips of the tegmina; tegmina about half covered by sides of pronotum, smoky-hyaline; undersurface and legs ferruginous. Near *A. projecta* Funkhouser but the pronotum does not overhang the head, and the tegmina are distinctly clouded.

TECHNICAL DESCRIPTION:

Head subtriangular, finely punctate and pubescent; base weakly arcuate and strongly sinuate; eyes large, ovate and black; ocelli conspicuous, equidistant from each other and from the eyes and situated slightly below a line drawn through centers of eyes; inferior margins of genæ sloping and weakly sinuate; clypeus subtriangular, projecting very little below inferior margins of genæ and continuing the apical outline of the face made by those margins, tip rounded and pilose.

Pronotum dull green, finely punctate, sparsely pubescent; metopidium triangular, about as broad as high, nearly vertical above the head with only a slight backward slope; median carina strongly pereurrent; humeral angles strong, triangular and sharp; pronotum highest behind humeral angles, roundly arcuate and then gradually sloping to the tip of the posterior process; sides of pronotum without ridges or impressions; posterior process heavy, tectiform, apex acute and extending almost to tips of tegmina.

Tegmina about half covered by sides of pronotum; dark smoky hyaline with brown spot at tip; base narrowly coriaceous and punctate; veins not prominent; five apical and three discoidal cells; apical limbus broad.

Sides of thorax and undersurface of body ferruginous; legs stout, simple, ferruginous, hind tarsi longest.

Length from front of head to tips of tegmina 6.5 mm.; width between tips of humeral angles 3.4 mm.

Type: Female.

Type locality: San Martin, Peru.

Described from a single specimen collected by Mr. Woytkowski in August 1936. Type in author's collection.

15. *Tynelia nigra* sp. nov. (Fig. 15)

Large, entirely black, punctate, pubescent; head projecting strongly forward with lateral margins distinctly flanged; dorsum gradually arcuate; posterior process extending just to tips of tegmina; tegmina about half exposed with very heavy black veins; legs and undersurface of body black.

TECHNICAL DESCRIPTION:

Head very long and projecting strongly forward, smooth, shining, dark brown, deeply sulcate on each side of lateral margin; base curved downward in middle; eyes large, subtriangular, gray-black; ocelli large, prominent, glassy, about equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; genæ foliaceous, thin, plate-like, strongly flanged; inferior margins of genæ strongly sloping and sinuate; clypeus flat, not extending below inferior margins of genæ, tip rounded and hirsute.

Pronotum black; finely punctate, sparingly pubescent; metopidium sloping, wider than high; median carina strongly percurrent; humeral angles heavy, triangular, blunt; dorsum low, gradually arcuate, somewhat flat in middle; sides of pronotum without ridges or impressions; posterior process heavy, subconical, apex sharp and just reaching tips of tegmina.

Tegmina about half exposed; hyaline with very heavy, black veins; base narrowly coriaceous and punctate; five apical and three irregularly shaped discoidal cells; third apical cell petiolate and transverse; apical limbus narrow; extreme tip black.

Sides of thorax and undersurface of body black; legs heavy, simple, black; hind tarsi longest.

Length from tip of clypeus to tips of tegmina 7.8 mm.; width between humeral angles 3 mm.

Type: Female.

Type locality: Leonpampa, Peru.

Described from a single specimen taken in December 1937 by Mr. Woytkowski. Type in author's collection.

16. *Vanduzea decorata* sp. nov. (Fig. 16)

Jet black with a bright orange band across the middle and with the humeral angles edged with yellow; eyes white; dorsum slightly depressed at middle; posterior process heavy, blunt and not reaching the tips of the tegmina; tegmina about two-thirds ex-

posed, hyaline with heavy black veins; undersurface of body black; legs yellow.

TECHNICAL DESCRIPTION:

Head vertical, subtriangular, shining black edged with yellow, smooth, not punctate, not pubescent; base extended slightly downward at middle, feebly sinuate; eyes large, ovate and white; ocelli large, prominent, conspicuous, pearly, farther from each other than from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genæ rounded, sloping, edged with bright yellow; clypeus broad, not extending below inferior margins of genæ, tip rounded and pilose.

Pronotum shining black with a large orange band across the middle, very finely punctate, not pubescent; metopidium sloping, twice as broad as high; median carina obsolete; humeral angles large, triangular, acute, edged with yellow; dorsum nearly straight but with a slight indentation at middle; posterior process heavy, broad, tip rounded and reaching a point about halfway between internal angles and tips of tegmina.

Tegmina about two-thirds exposed; hyaline with heavy black veins; base narrowly black, coriaceous and punctate; five apical and three discoidal cells; base of median apical cell petiolate and transverse; apical limbus narrow.

Length from front of head to tips of tegmina 4.5 mm.; width between humeral angles 2.2 mm.

Type: Female.

Type locality: Leonpampa, Peru.

Described from a single specimen collected in December 1937 by Mr. Felix Woytkowski. Type in author's collection.

17. *Thrasymedes virescens* sp. nov. (Fig. 17)

Large, green, coarsely punctate, not pubescent; femora and abdomen marked with black; dorsum flat and nearly straight; posterior process acute and reaching beyond internal angles of tegmina; tegmina entirely free and entirely hyaline with one discoidal cell; under surface strongly marked with black; legs simple.

TECHNICAL DESCRIPTION:

Head subquadrate, three times as broad as long, yellow, smooth, shining; base irregularly sinuate, lowest just mesad of the eyes on each side; eyes large, ovate, black; ocelli small, glassy, equidistant from each other and from the eyes and situated below a line drawn through centers of eyes; inferior margins of genæ sloping and sinuate; clypeus ovate, extending very little below inferior margins of genæ and continuing the ventral outline of the face made by these margins, tip rounded and pilose.

Pronotum low, flat, green, coarsely punctate, not pubescent; metopidium sloping, twice as wide as high; median carina obsolete; humeral angles

weak, rounded, broad; posterior process long, heavy, cylindrical at base and tricarinate at apex, tip tectiform, sharp, reaching to a point about one-fourth the distance from the internal angles to the tips of the tegmina; sides of pronotum concolorous, not ridged nor impressed.

Tegmina broad, entirely free, hyaline; base narrowly coriaceous and punctate; veins weak and brown; five apical cells; one discoidal cell; tip rounded; apical limbus broad.

Sides of thorax and undersurface of body black; margins of abdominal segments black; legs simple and fuscous; femora cylindrical and strongly marked with black; tibiæ triquerate; hind tarsi much longer than the others.

Length from front of head to tips of tegmina 7 mm.; width between humeral angles 2.7 mm.

Type: Female.

Type locality: Santo Domingo, Peru.

Described from two females both collected at the type locality in November 1937. Type and paratype in author's collection.

18. *Microtalis nigromarginata* sp. nov. (Fig. 18)

Fuscous with margins of head and pronotum bordered with black, finely punctate, not pubescent; metopidium broad and sloping; dorsum straight; posterior process acute and reaching just beyond internal angles of tegmina; tegmina hyaline, veins weak and obscure; undersurface of body yellow; legs simple and yellow.

TECHNICAL DESCRIPTION:

Head subquadrate, three times as broad as high, yellow, smooth, not punctate, not pubescent, shining; base weakly sinuate and strongly margined with black; eyes large, ovate and greenish; ocelli large, prominent, yellow, a little farther from each other than from the eyes and situated above a line drawn through centers of eyes; inferior margins of genæ sloping and sinuate; clypeus subovate, smooth, extending for about one-third its length below inferior margins of genæ, tip rounded.

Pronotum fuscous, shining, finely punctate, darker on metopidium; metopidium sloping, twice as broad as high; median carina obsolete; humeral angles broad, heavy and blunt; sides of pronotum strongly margined with black; dorsum straight and only weakly convex; posterior process straight, very sharp, tip black and reaching just beyond the internal angles of the tegmina.

Tegmina entirely free, hyaline; base narrowly coriaceous and punctate; veins weak and very obscure in basal area; four apical and no discoidal cells; tip roundly pointed; apical limbus broad.

Sides of thorax and undersurface of body yellow; area of abdomen marked with black; legs simple and uniformly yellow; hind tarsi longest.

Length from front of head to tips of tegmina 4.4 mm.; width between humeral angles 2 mm.

Type: Female.

Type locality: Tingo-Maria, Peru.

Described from a single specimen collected in September 1937 by Mr. Woytkowski. Type in author's collection.

PLATE XI

1. *Lycoderes luteus* sp. nov.
2. *Stylocentrus rubrinigris* sp. nov.
3. *Alchisme laticornis* sp. nov.
4. *Alchisme pinguicornis* sp. nov.
5. *Alchisme spinosa* sp. nov.
6. *Paragargara nigra* sp. nov.
7. *Aconophora erecta* sp. nov.
8. *Aconophora brunnea* sp. nov.

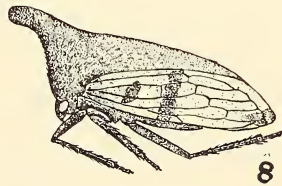
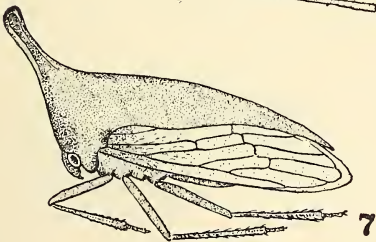
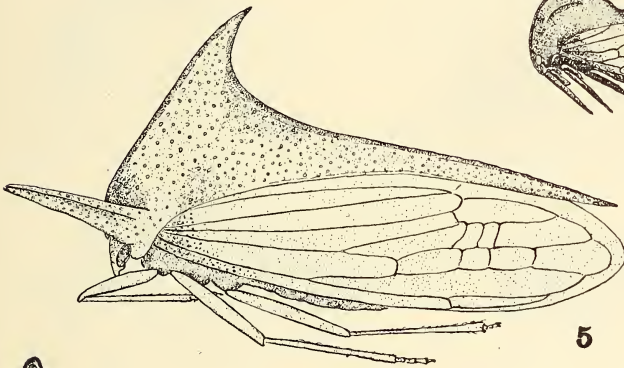
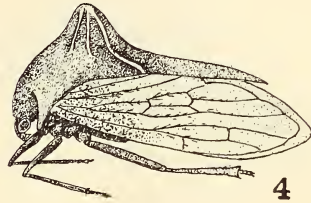
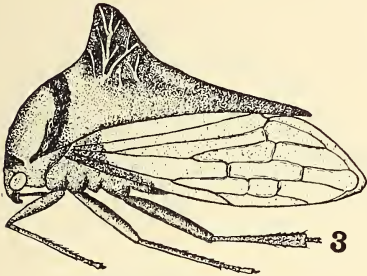
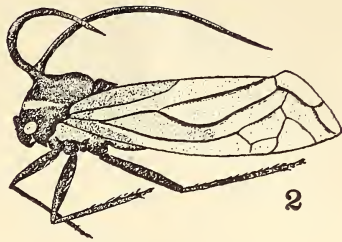
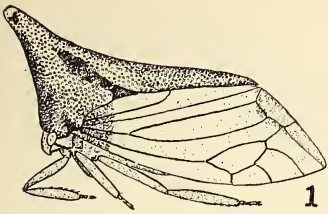
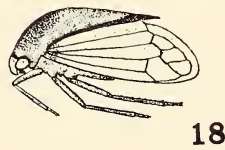
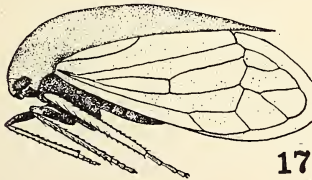
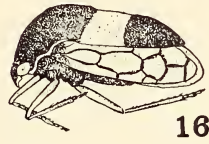
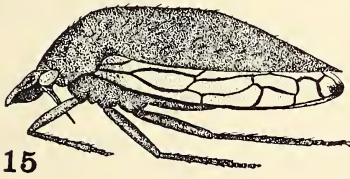
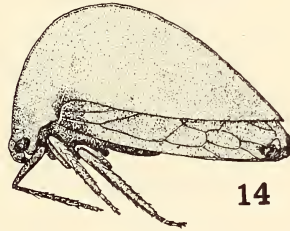
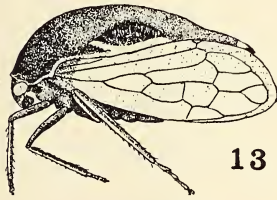
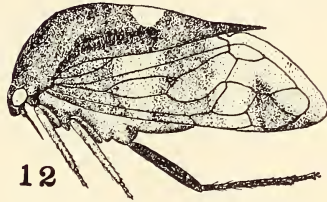
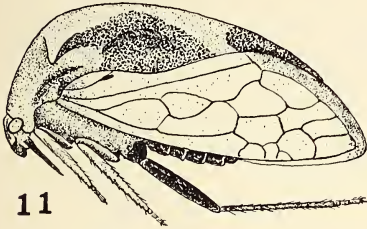
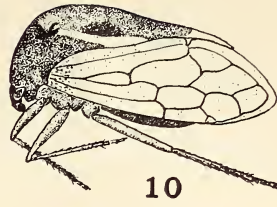
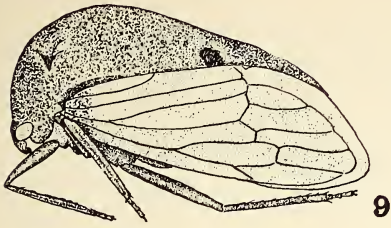


PLATE XII

9. *Sundarion nigromacula* sp. nov.
10. *Ceresa luteimaculata* sp. nov.
11. *Ceresa grisescens* sp. nov.
12. *Stictolobus nitidus* sp. nov.
13. *Stictolobus marginatus* sp. nov.
14. *Amastris peruviana* sp. nov.
15. *Tynelia nigra* sp. nov.
16. *Vanduzeeia decorata* sp. nov.
17. *Thrasymedes virescens* sp. nov.
18. *Microtalis nigromarginata* sp. nov.



PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF JANUARY 3, 1939

The annual meeting of the New York Entomological Society was held on January 3, 1939, in the American Museum of Natural History; President Moore in the chair with thirty members and visitors present.

The following were elected to active membership: Mr. A. Davidoff, Mr. M. Gadol, Dr. J. Johnston, Dr. R. E. Blackwelder, Mr. George F. McKenna.

The report of the auditing committee was accepted as read.

The following officers were elected for the year 1939:

President	DR. H. T. SPIETH
Vice-President	WILLIAM T. DAVIS
Secretary	LUCY W. CLAUSEN
Treasurer	PAUL T. RICHARD
Librarian	FRANK E. WATSON
Curator	A. GLENN RICHARDS

Executive Committee:

H. F. Schwarz
Dr. William Procter
Dr. F. E. Lutz
Dr. A. B. Klots
Henry Bird

Publication Committee:

Harry B. Weiss
John D. Sherman, Jr.
E. L. Bell
Dr. William Moore

Auditing Committee:

Dr. J. L. Horsfall
Max Kisliuk
G. B. Engelhardt

Delegate to the New York Academy of Sciences:

William T. Davis

The resignation of Mr. G. C. Hall was accepted with regret.

A report of the Richmond meetings was given by Dr. Horsfall, Dr. Argo, Dr. Spieth and Mr. Engelhardt.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF JANUARY 17, 1939

A regular meeting of the New York Entomological Society was held on January 17, 1939; President Spieth in the chair with forty-three members and visitors present.

Mr. Mutchler was appointed chairman of the meeting. Dr. Spieth spoke on "Some Methods of Biological Control." He gave the factual evidence upon which the theory of control is built, the methods of control of pests, relative state of present development and relative importance of each pest,

history of biological control, mechanical problems, and concluded his talk on the general value of biological control.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF FEBRUARY 7, 1939

A regular meeting of the New York Entomological Society was held on February 7, 1939; President Spieth in the chair with fifty-five members and visitors present.

Mr. Baumann spoke on color photography, and showed about 220 colored pictures, explaining the lens, timing, aperture and equipment used.

Mr. F. S. Blanton brought a breath of spring to the meeting by giving narcissus blooms to those present.

A. BACON, *Secretary pro tem*.

MEETING OF FEBRUARY 21, 1939

A regular meeting of the New York Entomological Society was held on February 21, 1939; President Spieth in the chair with forty-five members and visitors present.

The Secretary was instructed to write a letter of sympathy to Dr. William Moore and to extend wishes for his speedy recovery.

Dr. Payne, the speaker of the evening addressed the members on "Differential Growth in the Locust, *Locusta migratoria*."

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MARCH 7, 1939

A regular meeting of the New York Entomological Society was held on March 7, 1939, in the American Museum of Natural History; President Spieth in the chair with sixty members and visitors present.

Dr. Ruckes announced with regret the death of the eminent zoologist, Dr. Wilson, of Columbia.

The speaker of the evening, Mr. Edwin W. Teale, before showing his motion pictures, related some of the trials and tribulations he went through in his attempts to record the ways of insects on colored motion film. He felt, however, that the studies he made last year were only a beginning and this year he hopes to accomplish a great deal more because of his experience.

Dr. Louis Pyenson of the School of Applied Agriculture, Farmingdale, Long Island was nominated for membership.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MARCH 21, 1939

A regular meeting of the New York Entomological Society was held on March 21, 1939, in the American Museum of Natural History; President Spieth in the chair with eighty members and visitors present.

Mr. Kisliuk reported the death of Dr. W. E. Britton.

Dr. L. Pyenson of the Institute of Applied Agriculture, Farmingdale, Long Island, was elected to active membership.

Dr. Blackwelder presented a suggestion whereby all the old accumulated books, pamphlets and separates could be offered for sale to interested parties and in this way the Society would be able to realize some money on an otherwise unusable collection of material. Dr. Blackwelder and Dr. A. Glenn Richards were appointed by Dr. Spieth as a committee to consider this suggestion, and act upon it.

Mr. Vladimir Tuma then spoke upon the "Breeding of Cockroaches" the title of which, he explained, hardly covered the subject. Mr. Tuma's chief concern was to standardize tests for roach insecticides. In order to do this he used two types of roaches, German and American, but so far has concentrated on the German. Over a period of three years work he found that German roaches 17 weeks of age (at which time the females are about to lay their eggs) are the least susceptible to insecticides. This is also true of the *Periplaneta*. Although his work is not yet as complete on the American as on the German, Mr. Tuma found that the resistance of the American roach is greater to liquid insecticides as well as to pastes than that of the German.

Mr. L. E. Chadwick of Harvard University gave a very detailed account of his work on the flight of insects. By the use of lantern slides he pointed out the course of movement of the wings. This was then followed by high speed motion pictures.

As an added lesson in flight he showed Dr. Emerton's motion pictures of homing pigeons' and humming birds.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF APRIL 4, 1939

A regular meeting of the New York Entomological Society was held on April 4, 1939, in the American Museum of Natural History; Vice-President W. T. Davis in the chair with thirty-five visitors and members present.

The committee in charge of the sale of the Society's books and pamphlets reported that bidding was brisk and that there was every prospect of a good income from this sale. Bids may be received until the close of the meeting, Tuesday, April 18.

Dr. R. E. Blackwelder then spoke on "The Wiles and Trials of a West Indian Staphylinid Collector." His talk was illustrated by lantern slides. A motorcycle with a fully equipped side-car was his chief mode of traveling while on the islands. Dr. Blackwelder utilized all the well known tricks of collecting and improvised a few of his own. One of the innovations was the use of a large net on the top of a car driven along the countryside slowly at dusk. In that way he was able to get numerous rare and desirable species.

It was his impression that Island entomologists were conspicuous by their scarcity.

A general discussion of Dr. Blackwelder's paper brought the meeting to a close.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF APRIL 18, 1939

A regular meeting of the New York Entomological Society was held on April 18, 1939, in Roosevelt Memorial; President Spieth in the chair with forty-five members and visitors present.

It was reported that the sale of books and pamphlets sponsored by the Society was proceeding at a rapid pace and bids would be received only until the close of the evening's meeting.

Mr. H. L. Fellton, Box 207, Liberty Corners, N. J., was proposed for membership.

Dr. Bromley spoke upon the "Hurricanes and Their Effect on Insects." The effect of hurricanes are felt by trees as well as insect life. After the Texas hurricane of 1933 the insects most affected were those of large and more fragile structure such as Lepidoptera, certain Orthoptera, Neuroptera and Odonata. Some insects which were favored were the soil-inhabiting species which were aided by rainfall accompanying the storm. There was also an increase of mosquitos.

The hurricane of 1938 was too late in the season, however, to affect insects adversely. We will probably experience an increase in bark borers and beetles. In a survey of the territory hit by the hurricane of last fall Dr. Bromley pointed out that the youngest and oldest trees survived. There had been four days of rain preceding the hurricane and thus tree roots pulled easily. He predicted an increase in woodland insects, followed by a similar increase in predators and parasites.

After a general discussion of Dr. Bromley's paper the meeting was adjourned.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MAY 2, 1939

A regular meeting of the New York Entomological Society was held on May 2, 1939, in the American Museum of Natural History; President Spieth in the chair with forty-eight members and visitors present.

Mr. H. L. Fellton, Box 207, Liberty Corners, N. J., was elected to active membership.

The program committee announced that the next meeting of the Society would be in the nature of a social gathering. Dr. Needham had kindly consented to address the members at this time.

Dr. Richards reported that the income from the sale of books and pamphlets of the Society was \$42.06. The question of what to do with this money was referred to the Executive Committee.

Mr. Dietrich as chairman of the Field Committee announced that plans were being made for a field trip of the Society to take place on June 10 at the home of Mr. Olsen of West Nyack.

The speaker of the evening, Mr. Girth, began his discussion with a history of the entrance of the Japanese beetle into this country about 1916. The adult beetles begin to emerge about June 25 and reach a peak about July 25.

Since the eggs hatch in the fall the larvæ do the most damage in the fall and early spring.

After experimenting with various media it was found that the nematodes, *Neoplectana glaseri*, grow best in a veal infusion agar. Feeding upon this substance nematodes will increase 20 fold within a week. After being aerated and agitated for a week the nematodes are then ready to be placed in the soil. It takes one week to culture them and one week to aerate them and then they may be stored for three months.

Upon being spread on soil infested with Japanese beetles in the grub form the nematodes enter the grubs. They then begin to multiply in the host. In a week it dies and the nematodes enter the soil and are ready to attack other grubs.

The nematodes are applied to infested areas with ordinary sprinkling cans. This gives immediate quick coverage of areas. A period of two weeks is allowed to elapse before a recount is made.

Mr. Girth's talk was illustrated with slides showing the laboratory phase of the work.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF MAY 16, 1939

A meeting of the New York Entomological Society was held on May 16, 1939, in the American Museum of Natural History; President Spieth in the chair with seventy members and visitors present.

Because of the social nature of the meeting it was decided that the reading of the minutes of the last meeting be omitted.

Mr. Dietrich announced that there would be a field trip on Sunday, June 11, to West Nyack. Notices of routes and train schedules were sent out giving further details.

Dr. Spieth brought to the attention of the Society the fact that there were twenty-five members and subscribers who have been delinquent for at least the past three years. A motion was made and carried that these members receive a letter asking them to pay their debts and either pay for the JOURNALS they have received or return them.

Mr. M. H. Sartor was elected to membership.

Dr. Needham addressed the members on his recent trip to the West Indies.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF OCTOBER 3, 1939

A regular meeting of the New York Entomological Society was held on October 3, 1939, in the American Museum of Natural History; President Spieth in the chair with twenty-six members and visitors present.

Dr. Blackwelder reported that the Society would sponsor another auction. Bids may be made in three ways: (1) on the whole volume (2) on individual issues and (3) on individual articles.

Mr. Edwin Hunger of 4341 Richardson Ave., N. Y. C., was proposed for active membership.

The Secretary read a letter from Mr. Paul Sampson, Manager of the DuPont Co., extending to the members of the Society an invitation to visit the DuPont building at the New York World's Fair. Of particular interest is the Pest Control Section under the direction of Dr. M. D. Leonard.

Mr. F. E. Watson was elected to honorary membership and the JOURNAL was included in this membership.

The meeting was then given over to a discussion of notes on summer collecting by members.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF OCTOBER 17, 1939

A regular meeting of the New York Entomological Society was held on October 17, 1939, in the American Museum of Natural History; President Spieth in the chair with forty members and visitors present.

Dr. Blackwelder reported that more issues of the "Canadian Entomologist" had been found and were now in the auction. The auction was extended to the meeting a month from now.

Mr. Edwin Hunger was elected to active membership.

Dr. Spieth spoke to the members on his trip to Europe this past summer, especially his work on the Walker and Eaton types of mayflies in the British Museum of Natural History.

The meeting was adjourned at 9:00 P.M., and then turned over to the auction and informal discussion.

ANNETTE BACON, *Secretary pro tem*.

MEETING OF NOVEMBER 21, 1939

A regular meeting of the New York Entomological Society was held on November 21, 1939, in the American Museum of Natural History; President Spieth in the chair with fifty-five members and visitors present.

Dr. Spieth appointed a nominating committee consisting of Mr. E. L. Bell, Dr. C. H. Curran and Dr. Herbert Ruckes.

Miss Majorie Schwarz spoke on her trip through East Africa. Her talk was illustrated with lantern slides.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF DECEMBER 5, 1939

A regular meeting of the New York Entomological Society was held on December 5, 1939, in the American Museum of Natural History; President Spieth in the chair with twenty-eight members and visitors present.

Mr. William Bjerke, 655 E. 233rd Street, New York City, was proposed for membership.

Upon informing the Society of the death of Dr. Fall, Mr. Angell made a motion, which was carried, that the Secretary be instructed to write a letter of condolence to Mrs. Richmond, sister of Dr. Fall.

A motion made by Mr. Bell, and carried, instructed the Secretary to write a letter to Dr. Moore telling him that the Society is happy to learn of his recovery from his recent illness.

Mr. Davis exhibited a cave cricket, *Tachycines asynamorous* Adelung, new to the state of New York.

LUCY W. CLAUSEN, *Secretary*.

MEETING OF DECEMBER 19, 1939

A regular meeting of the New York Entomological Society was held on December 19, 1939, in the American Museum of Natural History; President Spieth in the chair with thirty-five members and visitors present.

A motion was made by Mr. Sherman and carried that the recommendations of the Executive Committee be accepted as follows:

1. That the sums realized from the auctions of publications recently held by the Society be placed in the general fund of the Society.

2. That the residue of odd numbers of the Casey Memoirs still in possession of the Society be placed with the individual in charge of Coleoptera at the American Museum with power to give these odd numbers to any individual or individuals interested in beetles who in his estimation can use them to advantage.

3. That it be recommended to the Society that an announcement be inserted in the JOURNAL to the effect that the line-cuts and half-tones of illustrations published in the JOURNAL in years past shall, in so far as they are still in existence, be available to the authors of the articles in connection with which they originally appeared provided that the cost of packing and shipping such line-cuts and half-tones shall be defrayed in advance by those claiming them. If claims for such plates are not made within six months of the time when the issue of the JOURNAL containing the announcement makes its appearance, the Society reserves the right to destroy the plates that are unclaimed.

4. That it be recommended to the Society that the insect parts of volumes 73 and 74 of the Zoölogical Record for the years 1936 and 1937 be purchased (payment to be made preferably on delivery) in order to insure the continuity of this series, from which the volumes in question have unfortunately disappeared apparently beyond recovery.

A motion was made by Mr. Bell, and carried, that the offer of \$30.00 for 600 signatures on hand belonging to the Society be accepted.

A motion was made by Mr. Kisliuk, and carried, that the residue of these signatures be distributed to anyone interested.

Mr. William Bjerke was elected to active membership.

Dr. Blackwelder then addressed the members on "The Modern Basis of Taxonomy" which will appear in the JOURNAL.

LUCY W. CLAUSEN, *Secretary*.

THE DEATH-FEINT OF TROX UNISTRIATUS
BEAUV.

BY HARRY B. WEISS

These brief notes represent the results of some observations made upon the death-feints of six specimens of *Trox unistriatus*.

These beetles feign death readily upon the slightest touch, unless they are handled constantly. In the death-feint attitude

DURATION OF SUCCESSIVE DEATH-FEINTS OF
TROX UNISTRIATUS BEAUV.

Beetle A (Seconds)	Beetle B (Seconds)	Beetle C (Seconds)	Beetle D (Seconds)	Beetle E (Seconds)	Beetle F (Seconds)
25	70	112	20	930	6
45	55	61	4	70	4
10	30	17	5	125	1
14	29	21	4	30	1
90	10	29	3	21	
25	22	9	4	8	
22	14	12	2	7	
15	13	23	1	8	
9	11	14	1	7	
4	6	35	1	5	
5	4	10		4	
2	2	7		2	
2	1	6		3	
		7			
		6			
		4			
		1			
		1			
		2			
		3			
		1			
		1			
		4			
		5			
		2			
		1			
Total	268	394	45	1,220	12
Average ...	20	15	4	94	3

the head is bent down and the femora of the first pair of legs advance toward the head. As the head bends down, the antennæ take a position under it, and before the femora of the first pair of legs move up, the tibiæ and tarsi assume a position parallel to and close against the anterior edges of the femora. The second and third pairs of legs are held close to the ventral surface of the body, with the femora, tibiæ and tarsi in the positions commonly assumed by other beetles in death feigning attitudes. The termination of the death-feint is usually gradual, the antennæ emerging first, or the tarsi of the first pair of legs. This relaxation then extends to the other legs more or less simultaneously.

The foregoing table exhibits the duration in seconds of the successive death-feints of six beetles, with an interval of four seconds between each death-feint, at a temperature of 80° F., and a relative humidity of 60 per cent.

Apparently there is a wide variation in the length of the death-feint of different specimens. In the above cases, it varied from one second to as many as 930 seconds, when the intensities of the outside stimulations were approximately constant. With the exception of beetles C and F, the number of successive death-feints ranged from 10 to 13. In F it was 4, and in C, it was 26. At the end of these numbers the death-feints were no longer produced and the beetles made continuous efforts to escape. It may also be noted that the tendency is for the death-feints to become shorter as they successively increase in numbers.

The New York Entomological Society

Organized June 29, 1892—Incorporated June 7, 1893

Certificate of Incorporation expires June 7, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P. M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 77th Street and Columbus Avenue.

Annual dues for Active Members, \$3.00; including subscription to the Journal, \$4.50.

Members of the Society will please remit their annual dues, payable in January, to the treasurer.

Honorary President, WILLIAM T. DAVIS

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Vice-President, MAX KISLIUK, JR.Federal Bldg., New York, N. Y.

Secretary, LUCY W. CLAUSEN.....American Museum of Natural History

Treasurer, DR. HERMAN T. SPIETH.....College of the City of New York, N. Y.

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Curator, C. E. OLSEN.....American Museum of Natural History

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WILLIAM T. DAVIS

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of the

NEW YORK ENTOMOLOGICAL SOCIETY

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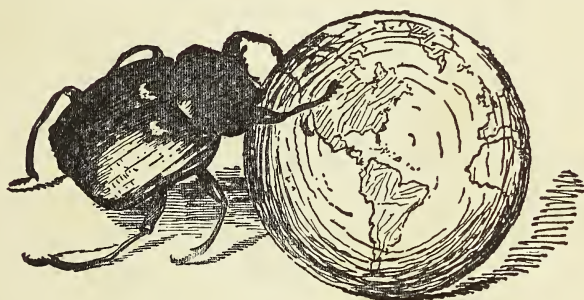
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Devoted to Entomology in General



Edited by HARRY B. WEISS

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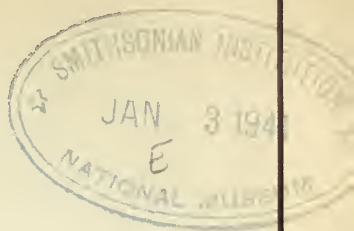
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VOL. XLVIII

DECEMBER, 1940

No. 4

SEASONAL ABUNDANCE OF EGGS OF THE CORN EAR WORM MOTH IN VIRGINIA

BY W. J. PHILLIPS AND G. W. BARBER

CEREAL AND FORAGE INSECT INVESTIGATIONS
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

INTRODUCTION

The determination of the seasonal abundance of the different stages of the corn ear worm (*Heliothis obsoleta* (F.)) is attended by so many difficulties that, in studying the seasonal history of the insect, investigators have usually restricted themselves to insectary rearings of isolated individuals under artificial conditions. A more complete knowledge of the seasonal history and abundance of the insect as it is found in nature was needed.

The fact that this insect passes part of its life in the soil makes field counts of pupation and emergence impracticable. The moths are rapid fliers and move about so freely that it is difficult to make accurate observations of their habits. Observations on the infestation of corn ears in the field may give information relative to seasonal abundance and life history, but it is by no means certain with what degree of accuracy the numbers of larvæ occurring at any time may be determined. On the other hand, observations to determine the abundance of eggs can be made much more easily and with much greater accuracy. The seasonal variations in egg abundance should indicate the prevailing moth population with a fair degree of exactness and should also indicate what the subsequent larval population will be. The occur-

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rence of eggs, therefore, should give the most accurate information obtainable of seasonal history and abundance of the insect.

One of the difficulties encountered in the determination of the seasonal history and abundance of the insect by observation of oviposition lies in the fact that corn is more attractive to the moths for egg laying at certain stages of its growth than at others. It is most attractive while the plants are in the fresh-silk stage, and least attractive while the plants are small or after they have ripened. In the latitude of Virginia corn may be planted during a period of more than 2 months. An early-maturing variety planted the first of April may begin to silk by mid-June, whereas corn planted in June may not begin to silk until September. Since plants with fresh silks are more attractive than others for oviposition, the concentration of eggs on plants during June, for instance, would be far greater on the early-planted than on later-planted corn. Therefore, the examination of a single planting of corn would not show the actual abundance of moths throughout the season, for, though eggs might be laid late in the season in great numbers, they would be deposited on plants in fields that were in more attractive stages of growth.

To determine the seasonal occurrence and abundance of eggs, numerous plantings of corn were made throughout the growing season at Charlottesville, Va., each year from 1921 to 1927, excepting 1923. Similar plantings were made at Richmond, Va., from 1924 to 1927. Such plantings, except during the early part of a season, provided plants continuously in the stages of growth favorable for oviposition. Fresh silks often appeared by the second or third week of July and were continuously present thereafter until the first week in October.

A number of representative plants were chosen from each plot, and, except when weather prevented, daily records were made of the number of eggs deposited on each plant. All eggs were removed each day except those on certain plants set apart for determination of the fate of the eggs. These eggs were marked and their positions noted, so that new depositions could be easily recognized. Observations of a given plant were discontinued 3 days after the silks had completely dried, or somewhat before roasting-ear stage. From these records it was possible to deter-

mine the average deposition of eggs per plant per day and to chart the seasonal occurrence and abundance of eggs. The advantage of this method of recording the eggs deposited on a number of plants in various stages of growth was that field conditions as found in the section in which these studies were made were approximately simulated except, of course, for seasonal variation in acreage. No definite planting date for corn is usually observed by farmers, and for this reason plants in various stages of growth are present in the field over a period of several months.

In the manner described, 16 studies were made of the local seasonal occurrence of the eggs of the corn ear worm in the localities and years mentioned. In all, complete oviposition records on 891 corn plants, representing 267 plots, were obtained. A total of 43,828 eggs were recorded, or an average of 49 eggs per plant. A total of 52,818 plant observations were made. The average rate of oviposition per plant per day was 0.83 for all years and localities.

PERIODS OF OCCURRENCE OF THE CORN EAR WORM IN VIRGINIA

In the latitude of Virginia several generations of the insect occur annually. Moths appear first between the last of May and the middle of June, and they continue to emerge from hibernation throughout June and July. Emergence is somewhat irregular because of the operation of several natural factors, such as precipitation and soil temperature. Since a generation may be completed in about 5 weeks, an overlapping of broods occurs from July onward through the season. For convenience in this study, and because generations cannot be recognized, the season was divided into two periods. The first period comprised roughly May, June, and July, and the second period consisted of August, September, and October.

CORN PLOTS USED IN THESE STUDIES

At Charlottesville, Va., three series of plots were used. These were designated as upland, bottom, and garden plots. The upland plots were located in a field of clay loam which sloped toward the west. Each plot consisted of three rows of field corn across the field. The bottom plots, also of field corn, were located in a river-bottom field about one-half mile south of the upland plots.

The garden plots each consisted of two rows of sweet corn in a vegetable garden in rich loam about 600 yards south of the upland plots. The plots at Richmond, Va., on level upland in sandy loam soil, consisted of field corn, and were similar in size to the upland plots at Charlottesville.

The upland and bottom plots at Charlottesville were planted to the same varieties of field corn and on similar dates. Common varieties of sweet corn were used in the garden plots, plantings being started earlier and being made at greater intervals than in the other plantings. The plantings in four localities, in different soil types, and at dates spread throughout the season, covered as wide a range of environment as it was possible to observe.

SEASONAL OCCURRENCE OF EGGS

The studies were begun each year when the earliest corn plants were about 8 inches tall, and continued until all corn had lost its attractiveness to the moths and egg laying on it had ceased.

The date when eggs were first found on corn in any year depended on two factors, (1) when moths emerged from hibernating pupæ, which was dependent on spring weather, and (2) the time when corn was planted and the rate at which it grew, also dependent on spring weather, making for earliness or lateness of the season. The date on which the first eggs were laid on corn varied about a month in different years. The earliest occurring eggs were found on May 21, 1925, at Richmond. The lateness of occurrence of corn in attractive stages of growth in the fall, and consequent occurrence of ear worm eggs on it, varied for similar reasons. The latest egg recovered on corn was on October 10 in Charlottesville upland plots in 1927. A record of egg recovery is given in table 1. A general summary of the results of this study is given in table 2.

Eggs were deposited on many days in each period. For each period, however, the proportion of days on which eggs were deposited, based on the total number of days of observation applicable to that period, was variable. Figure 1 shows the percentage of days in each period on which eggs were deposited. Within the first period the range was from 16.67 (bottom plots at Charlottesville in 1925) to 100 per cent (upland plots at Charlottesville in

TABLE 1.—Average occurrence of corn ear worm eggs on corn plants during each 5-day period during the season (number of eggs per plant per day)

Locality	Year	Environment	MAY		JUNE					JULY							
			21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	6-10	11-15	16-20	21-25	26-31	
CHARLOTTESVILLE	1921	upland	—	0.21	0.10	0.13	0.13	0.13	0.13	0.56	0.66	1.04	1.46	0.68	0.47	0.11	0.06
	1922	upland	—	.08	.03	.18	.09	.11	.16	.07	.16	.02	.09	.09	.14	.31	.25
	1922	bottom	—	—	.05	.13	.07	.05	.08	.12	.28	.06	.07	.03	.09	.12	.10
	1924	upland	—	—	—	—	—	.08	.25	.28	.41	.22	.22	.06	.09	.09	.04
	1924	bottom	—	—	—	—	—	—	—	.06	.26	.09	.09	.02	.00	.03	.03
	1925	upland	—	—	—	—	—	—	—	.05	.00	.00	.03	.00	.00	.02	.00
	1925	bottom	—	—	—	—	—	—	—	.00	.00	.00	.02	.01	.00	.00	.03
	1925	garden	—	—	—	—	.07	.11	1.24	.54	.95	.21	.05	.05	.09	.02	.02
	1926	upland	—	—	—	—	—	.21	.22	.14	.11	.09	.04	.04	.08	.11	.19
	1926	garden	—	—	—	—	.52	3.97	4.18	2.74	1.22	1.18	1.22	1.02	.82	.11	.13
	1927	upland	—	—	.00	.08	.13	.11	.26	.14	.14	.09	.04	.22	.37	.78	.35
	1927	garden	—	.00	.14	.51	.47	.64	3.87	.63	.63	.75	2.82	4.07	3.83	3.57	1.07
	RICHMOND	AVERAGE	—	.10	.06	.21	.21	.60	1.20	.45	.45	.41	.53	.53	.49	.44	.19
1924		upland	—	—	—	—	.06	.06	.19	.15	.07	.02	.01	.01	.01	.04	.04
1925		upland	.40	.09	.54	.47	.68	.31	.14	.04	.08	.16	.72	1.05	1.25	.74	.74
1926		upland	—	.28	.21	.15	.57	.40	.22	.12	.21	.53	2.33	.95	.45	.23	.23
1927		upland	—	2.70	1.05	.93	.57	.81	1.65	1.78	.96	.85	.84	1.37	.67	.12	.12
	AVERAGE	.40	1.02	.60	.52	.47	.40	.55	.52	.52	.33	.39	.98	.85	.59	.28	.28

TABLE 1.—(Continued)

Locality	Year	Environment	AUGUST					SEPTEMBER					OCTOBER			
			1-5	6-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	6-10
CHARLOTTESVILLE	1921	upland	0.05	0.09	0.26	0.52	1.06	1.98	2.54	6.16	5.33	6.53	—	—	—	—
	1922	upland	.16	.08	.13	.55	1.60	2.75	4.25	4.27	1.18	—	—	—	—	—
	1922	bottom	.03	.01	.17	.16	.29	1.39	2.67	4.48	2.42	1.15	—	—	—	—
	1924	upland	.17	.31	.11	.24	.23	.42	.36	.10	.12	—	—	—	—	—
	1924	bottom	.08	.16	.23	.18	.29	.04	.40	.39	.07	.24	.00	—	—	—
	1925	upland	.03	.03	.09	.14	.09	.50	.52	1.08	1.85	2.74	2.33	2.29	—	—
	1925	bottom	.03	.02	.16	.16	.18	.29	.42	2.08	7.03	5.86	5.50	2.07	1.00	.75
	1925	garden	.02	.07	.00	.03	.00	.07	.53	4.67	6.04	8.31	9.10	2.67	.95	.67
	1926	upland	.12	.05	.03	.32	1.23	1.30	1.63	2.89	2.98	1.59	4.53	5.92	—	—
	1926	garden	.03	.07	.00	.96	.69	.87	3.44	5.13	5.00	5.06	6.29	5.50	—	—
	1927	upland	.09	.08	.03	.01	.06	.06	.04	.12	.34	1.57	1.51	2.27	1.00	.07
	1927	garden	.12	.02	.00	.00	.02	.14	.37	.40	4.64	5.96	1.35	1.12	.68	—
	AVERAGE			.08	.08	.10	.27	.48	.82	1.43	2.65	3.08	3.90	3.83	3.12	.91
RICHMOND	1924	upland	.21	.06	.06	.00	.02	.02	.07	—	—	—	—	—	—	—
	1925	upland	.86	.77	1.04	1.90	4.08	11.22	28.07	30.96	31.94	14.82	10.00	—	—	—
	1926	upland	.05	.15	.28	.83	1.40	3.15	3.10	2.75	2.08	2.14	—	—	—	—
	1927	upland	.12	.05	.08	.15	.10	.07	.16	.23	.07	.18	.87	.00	.00	—
	AVERAGE		.31	.26	.37	.72	1.40	3.62	7.85	11.31	11.36	5.71	5.43	—	—	—

TABLE 2.—Summary of seasonal occurrence of eggs of the corn ear worm in Virginia

Location	Year	Environment	Number of plots	Number of planting dates	Number of days observed	Number of days on which eggs were found	Total number of plants under observation	Seasonal dates					First period			Second period			Ratio of abundance of eggs of the second to those of the first period
								First examination	First recovery of eggs	First appearance of silk	First deposition of eggs of a second period	Last examination	Total number of days of observation	Average number of eggs per plant per day	Maximum number of eggs per plant on any one day	Total number of days of observation	Average number of eggs per plant per day	Maximum number of eggs per plant on any one day	
CHARLOTTESVILLE	1921	upland	44	9	113	111	133	May 30	May 29	May 30	Aug. 1	Sept. 19	63	0.51	2.66	50	1.04	13.25	2.04
	1922	upland	21	10	111	101	42	May 29	May 2	May 29	Aug. 7	Sept. 16	70	.14	1.30	41	1.25	5.11	8.93
	1922	bottom	17	8	110	83	34	June 2	June 2	July 11	Aug. 7	Sept. 19	66	.08	.33	44	.93	6.14	11.62
	1924	upland	14	7	92	75	42	June 17	June 18	July 23	Aug. 1	Sept. 16	45	.15	.66	47	.25	1.50	1.67
	1924	bottom	10	5	90	53	30	June 27	June 30	July 29	Aug. 1	Sept. 24	35	.06	.41	55	.19	1.50	3.17
	1925	upland	18	9	97	63	54	June 25	June 27	Aug. 1	Aug. 6	Sept. 29	42	.02	.12	55	.45	9.00	22.50
	1925	bottom	18	9	104	63	54	June 25	June 13	July 28	Aug. 6	Oct. 9	42	.01	.19	62	.92	14.75	92.00
	1925	garden	8	8	118	65	24	June 12	June 15	June 24	Aug. 6	Oct. 9	55	.31	1.91	63	2.73	23.00	8.81
	1926	upland	18	9	95	92	90	June 16	June 18	July 22	Aug. 7	Sept. 29	46	.12	.52	49	1.36	10.60	11.33
	1926	garden	7	7	102	77	21	June 9	June 9	June 18	Aug. 7	Sept. 28	52	1.19	5.77	50	2.09	15.00	1.76
	1927	upland	18	9	122	90	54	June 4	June 7	July 21	Aug. 7	Oct. 10	57	.25	1.50	65	.75	5.88	1.00
	1927	garden	9	9	115	75	27	May 25	June 3	June 23	Aug. 7	Oct. 5	63	2.04	8.53	52	.28	15.66	.38
RICHMOND	1924	upland	5	5	88	51	30	June 10	June 13	July 28	July 28	Sept. 5	42	.07	.33	46	.06	.56	.86
	1925	upland	19	9	127	125	95	May 21	May 21	June 12	Aug. 5	Sept. 24	76	.55	1.36	51	7.89	46.35	14.35
	1926	upland	18	9	111	110	90	May 27	May 27	July 11	Aug. 4	Sept. 20	67	.54	2.57	44	1.35	4.09	2.50
	1927	upland	23	11	120	104	71	May 27	May 27	June 24	Aug. 7	Oct. 2	66	.83	4.80	54	.11	1.20	.13

1921 and at Richmond in 1927). In the second period the range was from 53.85 per cent to three records of 100 per cent.

These studies showed that, because of the widespread occurrence of the eggs throughout each season, corn plants would probably receive eggs regardless of planting date.

SEASONAL ABUNDANCE OF EGGS

The abundance of eggs in the first period was frequently somewhat irregular, but in 10 of the studies the distribution was so uniform that no definite peaks of occurrence were found. In four of the seasonal histories, where eggs were less evenly distributed, more than one peak of occurrence was found, and a single definite peak of abundance was found only in two instances.

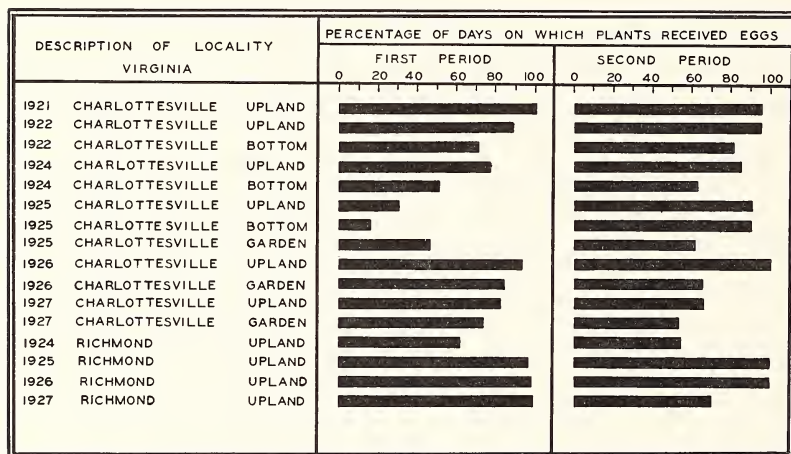


Figure 1. Percentage of days during the several studies of the seasonal history of the corn ear worm on which moths deposited eggs on corn plants. Based on the total number of days on which observations were made for the respective periods.

Numbers of eggs in the second period began to increase from the middle to the last of August, and reached clearly defined peaks of abundance from the middle to the last of September. During a period of about a month eggs usually were laid very plentifully. The egg laying during the second period was, therefore, usually concentrated within a relatively few days, in con-

trast to that of the first period, which was usually distributed over a larger number of days. The time of maximum abundance of eggs of the second period in 12 of the seasonal histories occurred either on a single date or extended over several days. However, in four instances the eggs were deposited more or less evenly during several weeks, and no well-marked peaks of abundance were found.

In all the seasonal occurrences studied, several days were found when the plants were relatively, sometimes entirely, free of eggs. The duration of the egg-free days, which usually occurred during the last week of July or the first week of August, ranged from a few days to 2 weeks or more.

In figure 2 the relative abundance of eggs of the first and second periods for each of the 16 seasonal histories studied is given. Eggs of the first period ranged in abundance from 0.01 egg per plant per day (bottom plots at Charlottesville in 1925) to 2.04 eggs per plant per day (garden plots at Charlottesville in 1927). In the second case eggs were 204 times as abundant as in the first. Eggs of the second period ranged in abundance from 0.06 egg per plant per day (upland plots at Richmond in 1924), to 7.89 eggs per plant per day (upland plots at Richmond in 1925). Second-period eggs at Richmond in 1925 were, therefore, 131.5 times as plentiful as in the same location in 1924.

NUMBERS OF EGGS DURING THE TWO PERIODS

A comparison of the numbers of eggs which occurred per plant per day in the two periods showed remarkable variation. This is illustrated graphically in figure 2. In each period, in the different seasonal histories, eggs ranged from scarce to abundant. Eggs of the second period were more abundant than those of the first period in 5 out of 6 years at Charlottesville, and in 2 out of 4 years at Richmond, and in 13 out of the 16 seasonal histories studied. In one seasonal history eggs of each period were equally abundant (Charlottesville upland plots of 1927). The numbers of eggs of the second period ranged from 0.13 to 92 times the number of eggs of the first period. These data are given in table 2.

The years 1924 and 1927 were apparently unfavorable for increase of this insect, while 1925 was the most favorable by far.

COMPARISON OF ABUNDANCE OF CORN EARWORM EGGS		
DESCRIPTION OF LOCALITY VIRGINIA	FIRST PERIOD	SECOND PERIOD
1921 CHARLOTTESVILLE UPLAND	■	■
1922 CHARLOTTESVILLE UPLAND	■	■
1922 CHARLOTTESVILLE BOTTOM	■	■
1924 CHARLOTTESVILLE UPLAND	■	■
1924 CHARLOTTESVILLE BOTTOM	■	■
1925 CHARLOTTESVILLE UPLAND	■	■
1925 CHARLOTTESVILLE BOTTOM	■	■
1925 CHARLOTTESVILLE GARDEN	■	■
1926 CHARLOTTESVILLE UPLAND	■	■
1926 CHARLOTTESVILLE GARDEN	■	■
1927 CHARLOTTESVILLE UPLAND	■	■
1927 CHARLOTTESVILLE GARDEN	■	■
1924 RICHMOND UPLAND	■	■
1925 RICHMOND UPLAND	■	■
1926 RICHMOND UPLAND	■	■
1927 RICHMOND UPLAND	■	■

Figure 2. Comparison of abundance of eggs of the corn ear worm during two periods of the year for 16 seasonal-occurrence studies. The areas of the squares indicate the number of eggs deposited per plant per day.

RELATIONSHIP OF PRECIPITATION TO ABUNDANCE OF EGGS

While many factors influence the population of this insect, as determined by the number of eggs found on corn plants, none seems to be more important than precipitation during the oviposi-

tion period. Dry weather is definitely favorable in enabling the moths to lay their full complement of eggs, and in permitting a high rate of hatching and survival of young larvae. Since drought is usually accompanied by high temperatures, such conditions cause more rapid development of the various stages of the insect. During the course of these studies one year of severe drought occurred, 1925, especially during September. The insect, in response to favorable conditions, built up enormous populations in September. Eggs of the second period at Charlottesville were 15.17 times, and at Richmond 14.35 times, as plentiful as eggs of the first period.

The greatest rainfall occurring during any year of the study was at Richmond in 1927, and as an effect of this, eggs of the second period were 0.13 times as plentiful as eggs of the first period. The records of 4 years of study at Richmond showed that the proportion of eggs of the second to those of the first period varied directly with the precipitation during the months from June to September. For Charlottesville this relationship was less direct, probably because of the influence of other factors. These data are given in table 3.

SUMMARY

Because of the habits of the corn ear worm, it is not easy to determine the seasonal occurrence or abundance of the insect by means of counts of the pupæ, moths, or larvæ. It was thought that this information could be obtained by counts of eggs deposited on corn plants, as the numbers of eggs might reflect moth abundance and later larval populations indirectly.

Daily examination of selected corn plants of successive plantings in two localities and four environments, during 6 years, gave data on 16 seasonal records of egg occurrence.

Much difference was found in the seasonal occurrence of eggs. This depended in part on earliness or lateness of the spring or fall.

In each seasonal occurrence studied there were a number of days in the last week of July or the first week of August when eggs were extremely scarce or wholly wanting. This time of egg scarcity was used to divide each season into two periods, the first

TABLE 3.—*Precipitation during the oviposition period and the numbers of eggs deposited on corn plants by corn ear worm moths*

Locality	Year	Precipitation during oviposition period					Number of eggs per plant per day ¹			Ratio of abundance of eggs of the second to those of the first period
		June	July	August	September	Total	First period	Second period	Yearly average	
CHARLOTTEVILLE	1921	3.49	3.60	1.65	1.65	10.39	0.51	1.04	0.66	2.04
	1922	4.73	3.94	4.87	1.00	14.54	.12	1.12	.32	9.33
	1924	6.83	2.71	4.87	6.43	20.84	.11	.22	.17	2.00
	1925	2.19	2.26	2.73	.89	8.07	.06	.91	.53	15.17
	1926	1.47	3.30	8.23	2.59	15.59	.35	1.48	.85	4.23
	1927	1.65	5.33	3.72	3.47	14.17	.79	.37	.62	.47
RICHMOND	1924	4.85	2.33	3.05	9.58	19.81	.07	.06	.06	.86
	1925	2.24	2.32	2.55	.93	8.04	.55	7.89	2.89	14.35
	1926	2.19	7.17	5.24	1.46	16.06	.54	1.35	.78	2.50
	1927	3.12	9.10	7.19	4.01	23.42	.83	.11	.62	.13

¹ Number of eggs observed divided by number of plant-days (number of plants observed times number of days of observation).

comprising roughly May, June, July and the second consisting of August, September and October.

Abundance of eggs varied greatly in different years. Eggs of the first period ranged from 0.01 to 2.04 per plant per day. Eggs of the second period ranged from 0.06 to 7.89 per plant per day. When most plentiful, eggs of the first period were 204 times as numerous as in the year of least abundance, and eggs of the second period were 131.5 times as numerous as when least plentiful.

While eggs of the second period were usually more plentiful than those of the first period, in 3 of 16 instances they were less abundant, and in one case the numbers were equal. Numbers of eggs of the second period ranged from 0.13 to 92 times those of the first period.

Precipitation seemed to be a principal factor in determining the abundance of the eggs. During seasons of much rain the ear worm population increased little. During seasons of little rain populations increased greatly.

DISTRIBUTION IN NEW JERSEY OF (MYLLOCERUS) CORIGETUS? CASTANEUS RÆLOFS

This weevil, catalogued in the "Fourth Supplement 1933 to 1938 (inclusive) to the Leng Catalogue of Coleoptera of America, North of Mexico," by Richard E. Blackwelder, Mount Vernon, N. Y., Dec. 1939, as "Curculionidæ: *Myllocerus castaneus* Rælofs. Jap. Sib.? N. A.," was taken (probably from oaks) at Montclair, N. J., in July, 1933, by A. S. Nicolay. A note by A. C. Davis, Takoma Park, Maryland, appearing in Bul. Brooklyn Ent. Soc., Vol. 30, 1935, p. 19, recorded this find, and the fact that L. L. Buchanan, of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, to whom a specimen was submitted for identification, "states that it evidently does not belong in the genus *Myllocerus*, and refers it tentatively to *Corigetus*."

In November 1939, a New York State Nursery Inspector, Mr. R. L. Clement, reported to the New Jersey Department of Agriculture that this insect had been found on Long Island and that it appeared to be causing considerable damage by feeding on oak foliage.

In the late summer of 1940, a rough survey was made in New Jersey to determine the distribution of the insect and the amount of damage caused by it. The present infestation can be described as extending from the northern tip of Bergen County to Denville in Morris County to Plainfield in Union County to Fort Lee in Bergen County. The insect was also found, close to the New Jersey shore, from Atlantic Highlands to Allenhurst. The few observations on feeding habits of this insect would indicate that although it does feed extensively on deciduous foliage (the oaks, primarily), heavy damage is not apparent until late in the season (late August or early September) and therefore injury to the host would be slight.—FRANK A. SORACI.

REVIEW AND SUMMARY OF STUDIES OF INSECTS ASSOCIATED WITH LEMNA MINOR*

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From 1931 to 1939 I have made observations of the animal population of *Lemna minor* found in the vicinity of Ithaca, New York. My interest has been centered upon insects that were more or less dependent upon Lemna, especially upon the Lemna fly, *Lemnaphila scotlandæ* Cress. This concentration led to the further study of parasites that emerged from the Lemna fly's puparia.

In making these surveys I have had little difficulty in obtaining duckweed, *Lemna minor*, for it abounds generally where there is quiet water, as in ditches, marshes, ponds, and small nooks along the banks of slowly flowing streams. Associated with *Lemna minor* are often large amounts of *Wolffia* and *Spirodela*, and infrequently small quantities of *Lemna trisulca*. The rainfall of a summer determines the available regions of quiet water on which Lemnaceæ can propagate. I have found tanks at the Cornell University fish hatchery (Plate XIV, Figure 4) and small ponds entirely covered by dense growths. The summer of 1939 was an unusually dry one for the vicinity of Ithaca and consequently many previous collecting spots were entirely bare. However, there was enough *Lemna minor* gathered to continue my records of animal life of this interesting association.

When I began these studies relatively few species of insects had been recorded as associated with duckweed. Among these there were two beetles entirely dependent upon this plant. A duckweed beetle, *Scirtes tibialis* Guer., was described in 1918 by W. C. Kraatz, who found it feeding entirely on *Lemna minor* in waters near Madison, Wisconsin. The other, a duckweed weevil, *Tanysphyrus lemnae* Fab., was reported by C. von Urban in the Entomologische Blätter (1922) as dependent upon duckweed for food. Lemna had been listed as the food plant of two aphids.

* Contribution of the Entomology Laboratory, Cornell University, Ithaca, N. Y.

In 1910 T. A. Williams gave duckweed as food of *Rhopalosiphum nymphaeae* Linn. and in 1918 H. F. Wilson and R. A. Vickery recorded *Lemna minor* as a food plant of *Aphis sambuci* Linn.

Records of other uses of duckweed by insects include a paper in 1911 by Wm. T. M. Forbes in which he mentioned *Lemna* thalli as the material used for making the case of the aquatic caterpillar *Elophila*. In the same report he said of this case, "It is distinguished from those of *Nymphula* and *Hydrocampa* by the lack of a sharp lateral edge," implying that the cases of these aquatic caterpillars were also constructed of *Lemna*. He observed that the "leaves of the case do not seem to be eaten." Another paper which appeared in 1919 was H. B. Hungerford's, "The biology and ecology of aquatic and semi-aquatic Hemiptera," in which he reported the use of the under surface of *Lemna* thalli for the attachment of the eggs of the aquatic bug, *Trepobates pictus* H. S. These appear to have been the only definite references to the relations of insects with *Lemna minor* before my observations began in 1931.

Since that time I have published one general paper (1934) on "The Animals of the *Lemna* Association," in which I listed fifteen species of insects, and a second more specialized paper (1939) on "The *Lemna* Fly and Some of its Parasites." In 1938 F. X. Williams described and figured a similar Ephrydrid, *Hydrellia williamsi* Cresson, as being found "on *Lemna*-covered water" in Hawaii and having "much the same habits as *Lemnaphila scotlandae* Cress."

My own observations have been made on the following more permanent resident insects in the *Lemna* association: one Collembolan (*Sminthurus aquaticus* Bourlet), one Hemipteran (*Mesovelius bisignatus* Uhl.), one Homopteran (*Rhopalosiphum nymphaeae* Linn.), one Coleopteran (*Tanysphyrus lemnae* Fab.), one Lepidopteran (*Nymphula oblitalis* Wlk.), one Dipteran (*Lemnaphila scotlandae* Cress.), and three Hymenopteran parasites (*Opius lemnaphilae* Muesebeck, *Trichopria angustipennis* Muesebeck, *Trichopria paludis* Muesebeck).

The habits of these *Lemna* insects may be summarized as follows:

The diminutive spring-tail, *Sminthurus aquaticus* Bourlet,

jumps about on the floating mats of duckweed. Occasionally pairs will be seen to jump together, the yellow colored male being carried by the mauve colored female. The male has a clasping device on the second and third antennal segments composed of hooks and tubercles. These lock around the straighter antennæ of the female. The pair meet face to face, lock antennæ, and then, the female raises the male at an angle varying from a few degrees to as many as ninety. Sometimes a pair will remain together in this fashion for more than an hour. Duckweed serves this species as a source of food and also as a place for depositing the eggs. Many small holes are made in the thalli in the process of the prolific egg laying. Some idea of the damage to the plant can be gained from Plate XIII, Figure 3.

The bright green nymphs of the water strider, *Mesovelis bisignata* Uhl., are common on duckweed. The nymphs run quickly over the thalli and can easily dart out over the open water without breaking through the surface film. *Lemna minor* functions as a convenient plant in which the adults can lay their eggs. The elongate-oval eggs with curved necks are inserted singly between the epidermal layers of the Lemna thallus, their tips being exposed on the upper side, where they appear as shiny, membranous, ringed spots. Relatively little destruction of Lemna is caused by these carnivorous bugs.

The "pond-lily Aphid," *Rhopalosiphum nymphææ* Linn., is always very abundant in my collections. These aphids move about on the thalli and on the water, apparently unhindered by any moisture on their tarsi. They are very prolific. Viviparous females produce young almost daily during August. They feed upon the sap in Lemna thalli. One aphid may remain on a single plant for hours. No appreciable injury to the duckweed seems to result from the microscopic feeding punctures of this aphid and evidently the loss of sap is easily overcome by the natural metabolic processes in the plant.

The duckweed weevil, *Tanysphyrus lemnae* Fab., is commonly found in the egg, larva, and adult stages on floating Lemna. The pupa is less frequently seen. In the laboratory pupæ were obtained by placing grown larvæ in masses of sphagnum and leaving them there to pupate. This is the method I offered

in 1937 (Culture Methods, p. 480). Scattered clumps of *Lemna* thalli on moist earth also served as satisfactory cover under which wandering larvæ pupated. The mining larvæ devour the green interior of the thalli, leaving whitened plants, while the adults use their snouts to eat out spherical holes from the upper side of the *Lemna*. The destruction is very great, as may be seen in Plate XIII, Figure 2.

An aquatic case-making moth, *Nymphula* (*Hydrocampa*) *obliteralis* Wlk., is usually present in collections of duckweed. A dirty-whitish larva binds together overlapping thalli for a case. When deprived of one case, it proceeds to make a new one immediately. It nibbles off bits of duckweed for food. In the laboratory a single larva was placed with a quantity of *Lemna* in a Syracuse watch glass. This insect ate so many of the plants that only a few were left for its pupal case. Certainly *Lemna minor* is used for the growth of this moth.

The *Lemna* fly, *Lemnaphila scotlandæ* Cress., was discovered by me in 1933 and sent to Mr. E. T. Cresson for determination. It was found by him to be a new genus and species of the Ephyridae. It is very small (length 1.2 mm.); so small that it has the unique ability among all the *Lemna* insects of being able to pass through its whole life cycle on and within a single thallus. However, it is not strictly limited to a single plant. It may be found moving from one thallus to another, even crossing intervening stretches of open water. The larva is a miner, and on hatching it bores into the center of the thallus for food and shelter (Plate XIV, Figure 9). Here, also in the mine, the amber-colored puparium is found (Plate XIV, Figure 6). Normally there is only one pupa in a plant. However, recently, I found two pupæ crowded in a single thallus. The adult fly (Plate XIV, Figures 7, 8, 10-12) crawls out of the puparium between the epidermal layers of the plant and walks about on the duckweed. Very soon it begins to eat by gouging out portions of *Lemna*, leaving characteristic parallel streaks (Plate XIII, Figure 1). These peculiar markings on thalli prove an aid in detecting the presence of the *Lemna* fly in any quantity of duckweed. The feeding activities of this fly result in the almost complete destruction of the thalli. The female attaches her dainty melon-

shaped eggs to the margin of the thallus, as shown in Plate XIII, Figure 1 and Plate XIV, Figure 5.

Three specific parasites on the Lemna fly (Plate XVI) were likewise unknown. One has been determined as a new species of *Opius* (*O. lemnaphilæ* Muesebeck) and two as new species of *Trichopria* (*T. angustipennis* Muesebeck and *T. paludis* Muesebeck). All of these parasites emerge from fly puparia, leaving tell-tale holes in the empty shells, as shown in Plate XVI, Figures 20 and 21. Comparison of the numbers of these parasites in 1938 and 1939 revealed a marked reduction in the total number found in 1939 but a relatively constant ratio of the different species. In 1939 as in 1938 there were more individuals of *Trichopria* than of *Opius*. Of the *Trichopria* there were three times as many *T. angustipennis* as *T. paludis*. Males predominated.

In addition to these resident Lemna insects, all of which are of some importance in the economy of the plant, there are several transient visitants and chance associates commonly present. These are included below in a comprehensive list* of insects of the Lemna association.

COLLEMBOLA

Sminthurus aquaticus Bourlet

Podura aquatica—Larger than *S. aquaticus*, found rarely.

ORTHOPTERA

Undetermined nymphs of crickets—Observed running over a mat of duckweed. Captured individuals nibbled edges of the thalli.

EPHEMERIDA and ODONATA

Undetermined nymphs—Foragers among the roots of duckweed.

THYSANOPTERA

Limothrips cerealium Hal.—Probably from nearby grasses.

* The taxonomic sequence is that followed by Leonard in *A List of the Insects of New York*. Cornell Univ. Agr. Ex. Sta. Mem. 101, Aug. 1926.

HEMIPTERA

Mesovelia bisignata Uhl.

Trepobates pictus H. S.—Hungerford (1919) described and showed figures of eggs on the under surface of floating duckweed.

Gerris sp. Found on surface of Lemna mat.

<i>Notonecta</i> sp.	} Common aquatic bugs that move among the roots of Lemna.
<i>Plea striola</i>	
<i>Ranatra</i> sp.	
<i>Corixa</i> sp.	

HOMOPTERA

Aphis sambuci Linn. Not observed by me.

Rhopalosiphum nymphæ Linn. Very common.

COLEOPTERA

Tanysphyrus lemnae Fab.

Scirtes tibialis Guer. Not observed by me.

Haliphus sp. Larvæ and adults scurry among roots.

Laccophilus sp. Larvæ.

Hydroporus sp. Lays its eggs singly on the pendant Lemna roots.

Tropisternus lateralis Fab. Larvæ observed foraging among roots.

TRICHOPTERA

Limnophilus combinatus Walk. Used bits of Lemna in constructing its case.

LEPIDOPTERA

Nymphula oblitalis Wlk.

Elophila sp. Not observed by me.

DIPTERA

Lemnaphila scotlandæ Cress.

Hydrellia williamsi Cress. Not observed by me.

Corynoneura scutellata Winn. Larvæ, pupæ, adults.

Dasyhelea traveræ Thom. Larvæ, pupa.

Tetanocera sp.

Culex sp. Eggs, larvæ, pupæ.

Anopheles sp. “ “ “
Chironomus sp. Cases.
Odontomyia sp. Larvæ and pupæ.
Eristalis tenax—Larvæ.

HYMENOPTERA—All parasites.

<i>Opius lemnaphila</i> Muesebeck	} Parasites of Lemna fly
<i>Trichopria angustipennis</i> Muesebeck	
<i>Trichopria paludis</i> Muesebeck	
Undetermined genus near <i>Aphanta</i> Foerster	
<i>Polynema</i> sp. Parasite of Mesovelgia eggs embedded in Lemna thalli.	
<i>Tiphodytes gerriphagus</i>	
<i>Anaphoidea pullicrura</i>	

In a summary like this I cannot refrain from mentioning the unexpected manner in which new fields of investigation often present themselves. It was while I was searching for Hydrophorus eggs in 1931 that these studies of the Lemna association began. I found the beetle eggs glued to the roots of duckweed. Upon looking through library sources I could discover no ecological study of the very common pond plant, *Lemna minor*. Thereupon, I undertook what has been a labor of love and what promises to be a life long inquiry into the wonders of this diminutive society.

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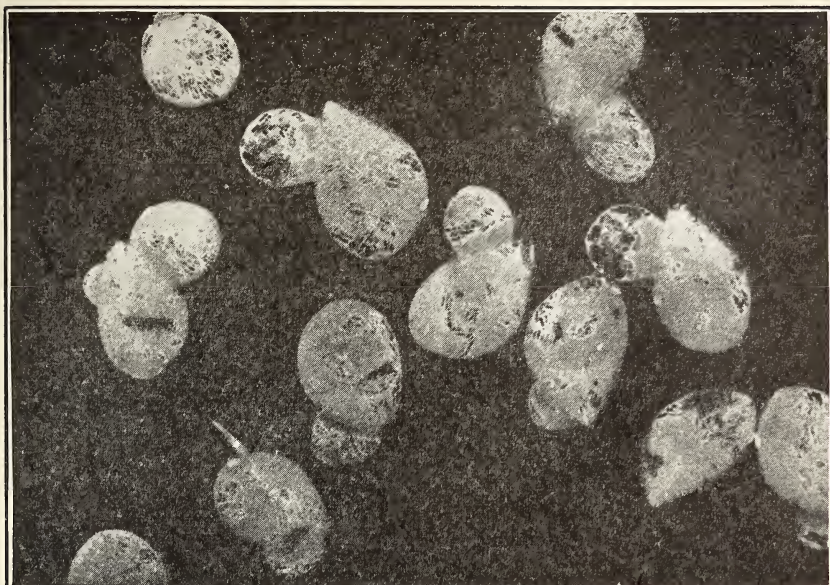
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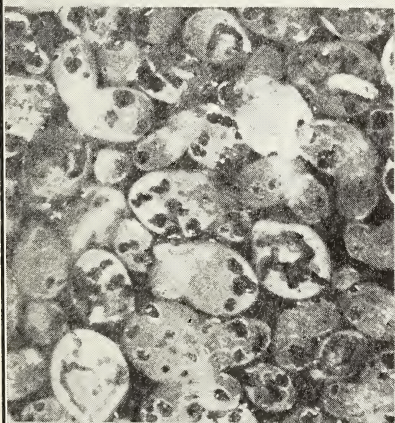
PLATE XIII

Infested Lemna, showing injuries

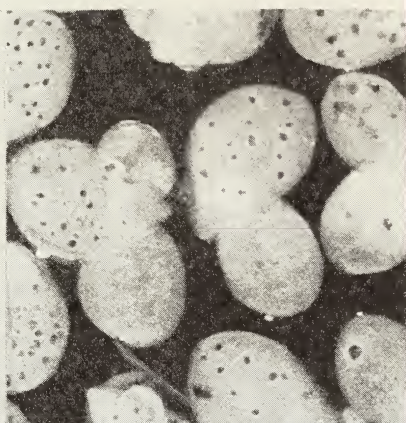
- Figure 1. The work of the adult Lemna fly, *Lemnaphila scotlandæ* Cress., which appears as parallel gougings. Nine of the thalli show eggs of this fly on their margins.
- Figure 2. The work of the duckweed weevil, *Tanysphyrus lemnae* Payk., showing the round feeding punctures made by the adult weevil and the irregular linear mines of the larva. One larva is visible through the transparent epidermis in a mine in the upper right.
- Figure 3. The work of the collembolan, *Sminthurus aquaticus* Bourlet. The round holes are the excavations in which the eggs were deposited singly.



1



2



3

PLATE XIV

- Figure 4. A tank at the Fish Hatchery of Cornell University, Ithaca, N. Y., showing a thick floating mat of lemna, the joint habitat of the lemna fly, the case-bearing moth, the Lemna weevil, the pond-lily aphid, the water strider, and the Collembolan.
- Figure 5. The ribbed and sculptured egg of *Lemnaphila scotlandæ* Cress. The micropyle is seen on the right.
- Figure 6. Empty puparium showing the rupture through which the fly has emerged.
- Figure 7. Wing of the Lemna fly.
- Figure 8. Antenna of same.

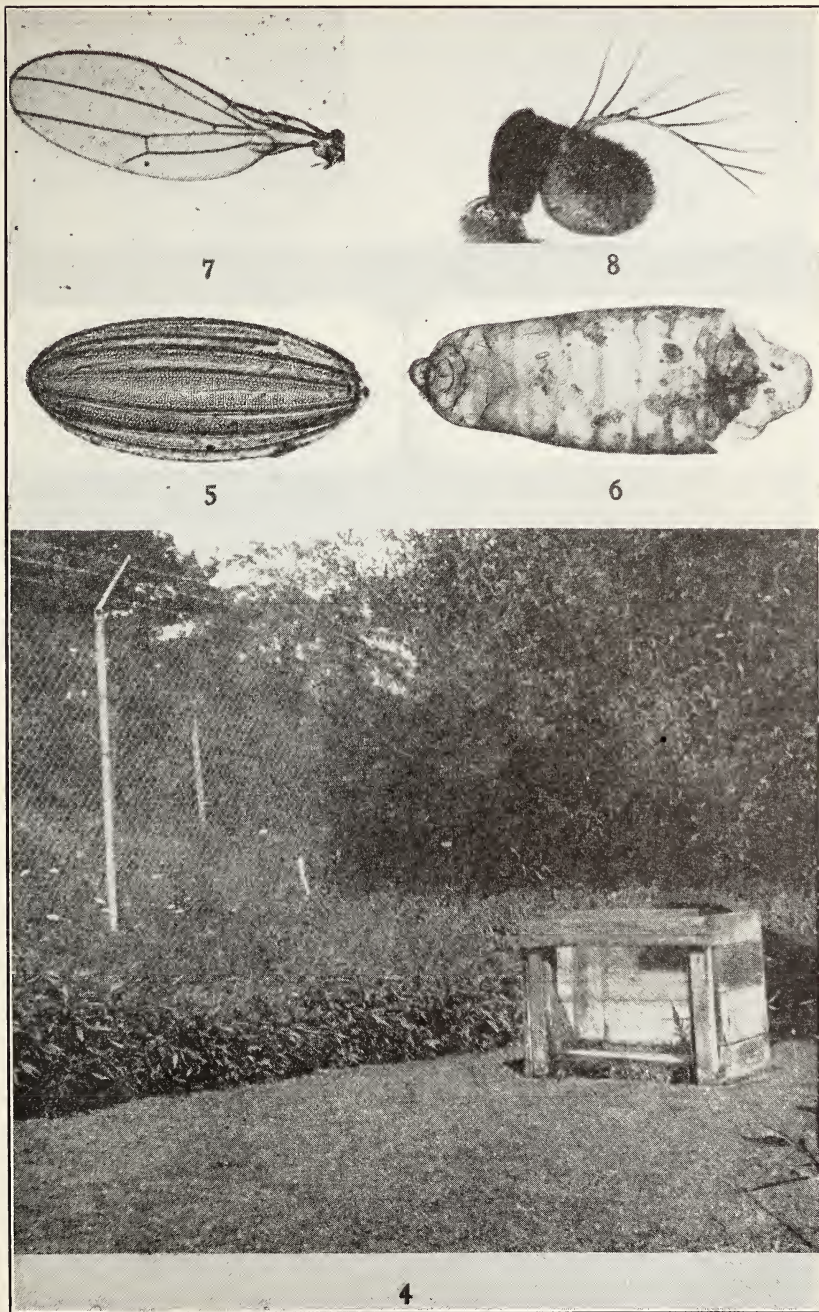
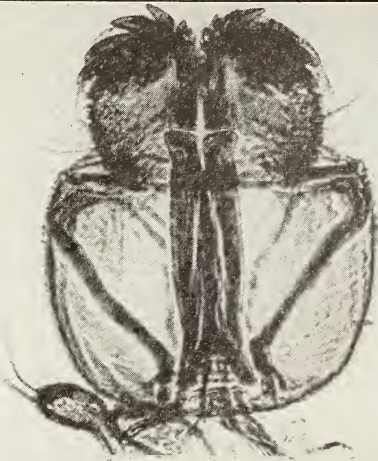


PLATE XV

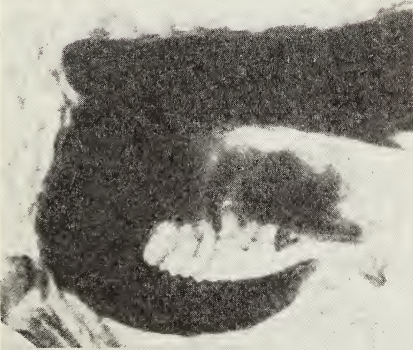
- Figure 9. Tip of the mouth-hooks of the larva of *Lemnaphila scotlandæ* Cress., showing the serrated margin of the inner surface of one hook. The other hook of the pair, diverging in position, shows dimly, being out of focus. A palpus shows faintly in the lower left.
- Figure 10. Adult Lemna fly.
- Figure 11. Tip of proboscis of same with labella retracted.
- Figure 12. The same, more enlarged and with labella expanded, showing the hooks that gouge the parallel rows of holes in the Lemna thallus. A labial palpus appears at the left below.



11



12



9

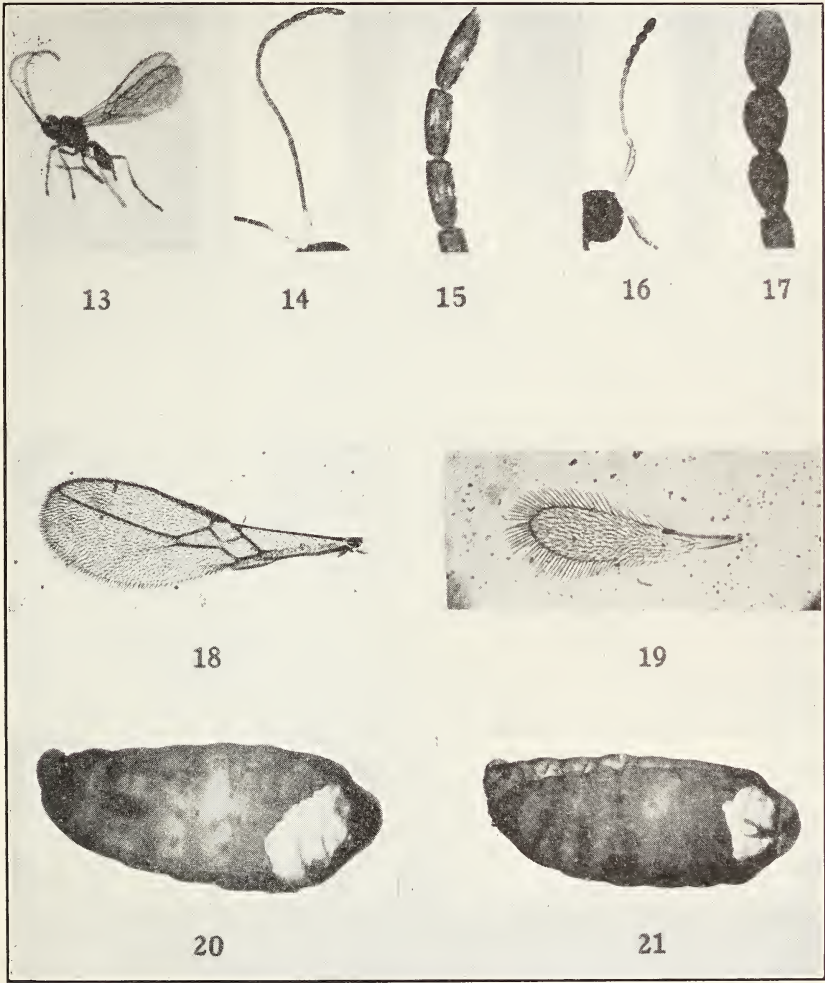


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PLATE XVI

Parasites of *Lemnaphila scotlandæ* Cress.

- Figure 13. *Opius lemnaphilæ* Muesebeck, adult female.
Figure 14. Antenna of same.
Figure 15. Terminal segments of same, showing sensillæ.
Figure 16. Antenna of *Trichopria angustipennis* Muesebeck.
Figure 17. Terminal segments of same, showing pit-like sensillæ.
Figure 18. Wing of *Opius lemnaphilæ* Muesebeck.
Figure 19. Wing of *Trichopria angustipennis* Muesebeck.
Figure 20. Empty puparium of *Lemnaphila scotlandæ* Cress., showing the large hole from which *Opius lemnaphilæ* Muesebeck has emerged.
Figure 21. Empty puparium of *Lemnaphila scotlandæ* Cress., from which *Trichopria angustipennis* Muesebeck has emerged.



THE NORTH AMERICAN SPECIES OF THE GENERA
LEUCOPHORA ROBINEAU-DESVOIDY AND
PROBOSCIMYIA BIGOT (MUSCIDÆ,
DIPTERA)

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The genus *Leucophora* Robineau-Desvoidy¹ belonging to the subfamily Anthomyiinae is of particular interest to students of insect life on account of the fact that the larvæ, so far as is known, live asinquilines² or parasites³ in the nests of solitary bees and wasps. It is recorded that the flies of many of the species belonging to this genus have the habit of shadowing bees and wasps as the latter approach their burrows, which are situated in sandy or gravelly soils.⁴ In this way the nests of hymenopterous hosts are probably detected by the female for purposes of oviposition. Despite these peculiar habits the adults of the group are not to be readily distinguished on the basis of generic characters from many species occurring in allied groups associated with *Hylemyia sens.-lat.* The flies of the genus *Leucophora* differ principally but not invariably by having the genal, facial and occipital regions of the head more buccate, interfrontalia in female narrower, frons in this sex approaching the proportions of that in male. The thorax is robust and abdomen in male conical and rarely longer than thorax, ovipositor armed with recurrent spines on anal palpi except in *maculata*, legs proportionately stout, wings with costal thorns vestigial, *m-cu* cross veins in many species

¹ In the sense of *Hylephila* and *Hammomyia* (Rondani) Coquillett. Proc. U. S. Nat. Mus., 1910 XXXVII p. 560.

² Huie, L. H. The habits and life history of *Hylemyia grisea* Fall., an anthomyid fly new to the Scottish fauna. The Scottish Naturalist, 1916 No. 49 Jan. p. 13-20.

³ Séguy, E. Contribution a l'étude des diptères anthomyides du genre *Hylephila*. Comptes rendus du Congrès des Sociétés savantes en 1925, 1926 p. 474.

⁴ Collin, J. E. A contribution towards the knowledge of the anthomyid genera *Hammomyia* and *Hylephila* of Rondani (Diptera). Trans. Ent. Soc. London, 1921 Pt. 111 p. 305-326.

oblique and sinuate and veins *R.*₄₊₅ and *M.*₁₊₂ convergent distad. Hypopygium and copulatory appendages in male of normal structure, not shining; in both sexes the apical scutellar setulæ are more robust than those of *Prosalpia*. The arbitrary nature of such a combination of characters may, without further knowledge, serve only to confuse rather than to clarify the definition of the genus. Undoubtedly one of the most important sources of information relating to the scope of the genus is to be found in the facts concerning the peculiar habits of the species.

Most authors have treated the group as composed of two segregates, and have applied to them Rondani's names *Hylephila* and *Hammomyia* respectively. In dealing with North American species this classification seems scarcely practical owing to the intergrading of many of the characters proposed for the separation of the different segregates. I have been unable to find additional characters that might help to support Rondani's action, and hence have assembled the species into one genus under the name *Leucophora* Robineau-Desvoidy, as proposed earlier by Coquillett.⁵

The following species are recorded as occurring in North America:⁶

- Leucophora albiseta* (von Roser)
- johnsoni* (Stein)
- maculata* (Stein)
- marylandica* (Malloch)
- obtusa* (Zetterstedt)
- sociata* (Meigen)
- unilineata* (Zetterstedt)
- unistriata* (Zetterstedt)
- fusca* n. sp.
- annexa*, n. sp.

Genus *Leucophora* Robineau-Desvoidy

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⁵ Loc. cit., p. 560.

⁶ *Hammomyia setigera* Johannsen (Trans. Amer. Ent. Soc., 1916 XLII p. 387) belongs to *Hylemyia*, being closely related to *H. inornata* Stein.

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Pt. VII Fasc. 2 p. 189 . . . Curran, Fam. Gen. N. A. Dipt.,

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Anthomyia (Hammomyia) Pandellé, Rev. ent. France, 1901 XX

p. 203, 299.

Genotype *Leucophora cinerea* Robineau-Desvoidy (= *Aricia albescens* Zetterstedt).

The genus *Leucophora* was described by Robineau-Desvoidy (1830)⁷ for the reception of five nominal species, none of which have since been recognized with any degree of confidence by subsequent authors. A careful study of the original description of genus and species has lead me to the conclusion that the same general group is here depicted that was later to be described by Rondani as two segregates.

Macquart (1835) apparently did not recognize Robineau-Desvoidy's genus, and forthwith cited the first four species of *Leucophora* as a part of his heterogeneous group *Chortophila*.

Rondani (1877) in dealing with the classification of Italian diptera erected the allied genera *Hylephila* and *Hammomyia*, and designated *Musca buccata* Fallén as the type of the former genus and *Aricia albescens* Zetterstedt as the type of the latter. In the case of *albescens* the author included in synonymy the species *Leucophora cinerea* Robineau-Desvoidy.

Coquillett (1901) in a preliminary list of the types of anthomyid genera designated *L. cinerea*, the third of five original species, as the genotype of *Leucophora*. Stein (1907) in his catalogue of palæarctic diptera cited *Leucophora* and *Hylephila* as synonyms of *Hammomyia* Rondani, and recorded *cinerea* and *albescens* among the synonyms of *Hammomyia albiseta* (von Roser). Coquillett (1910) in his later compilation of the type species of North American genera of Diptera included both of Rondani's genera as synonyms of *Leucophora*, accepting the name *Leucophora cinerea* in the sense of *Aricia albescens* Zetterstedt.

Subsequent authors (Stein, 1916, 1920) (Collin, 1921) (Séguy, 1923, 1925) (Malloch, 1921, 1934) (Karl, 1928) have maintained in a large measure the classification proposed by Rondani, although some doubt has been expressed concerning the validity of *Hylephila* as a name for one of the genera, owing to its possible preoccupation in *Lepidoptera*.

⁷ Citations of literature are given in abbreviated form in the synonymy, the year of publication being inserted within parentheses.

Séguy (1937) in his recent monograph on the Muscidae of the world combined both of Rondani's segregates into one genus under the name *Hylephila* Rondani.

In my opinion the name *Leucophora* was rendered valid by Coquillett's action in designating *Leucophora cinerea* Robineau-Desvoidy as the type of the genus. I have regarded the identity of *cinerea* as equivalent to that of *Aricia albescens* Zetterstedt, according to the consensus of opinions expressed in the literature. Zetterstedt's species is the genotype of *Hammomyia* Rondani, and on that account I have considered *Hammomyia* as a synonym of *Leucophora*. I have come to the conclusion that the generic name *Hylephila* as used by Rondani cannot stand owing to its preoccupation by Billberg.⁸ If Rondani's group is to be maintained it seems that a new name should be proposed to displace *Hylephila*. This genus possesses priority over *Hammomyia*, hence in any attempt to merge the two groups it would appear that the name *Hammomyia* would be sunk in synonymy. However in my opinion the need for a new name does not arise, if for no other reason than the fact that there already exists the prior claims of *Leucophora* Robineau-Desvoidy.

I have not thought it advisable, at least for the purposes of this study, to make any further reference concerning the possible status of the remaining species described in *Leucophora* because of lack of evidence or authority regarding their probable identity for specific purposes.

⁸ The name *Hylephila* was employed firstly in 1820 by Billberg (*Enumeratio Insectorum in Museo Billberg*, 1820 p. 81) to denote a genus in Lepidoptera. Although the validity of Billberg's genera has been indirectly questioned by Walsingham and Durrant (*Revision of the nomenclature of micro-lepidoptera*. Ent. Month. Mag., 1902 XXXVIII p. 163-170) and later by others on account of the unfortunate circumstances surrounding Billberg's work these authors evidently did not take into consideration the attempt made by Scudder (*Historical sketch of the generic names proposed for butterflies: A contribution to systematic nomenclature*. Proc. Amer. Acad. Arts Sciences, 1875 X p. 193) to revive Billberg's genus *Hylephila*. In Scudder's treatment of the genus the names of three original species are retained, of which *Papilio phylaeus* Drury is selected as the genotype of *Hylephila*. The authorship of the genus is credited to Billberg. In my opinion this action served to validate the name *Hylephila* Billberg for the group.

KEY TO MALES

1. Mid tibia with a bristle on anteroventral or mid ventral surface 2
- Mid tibia with no bristle on either ventral surface 7
2. Notopleural callosity with several setulæ 3
- Notopleural callosity devoid of setulæ 4
3. Scutellum fuscous on lateral and ventral surfaces; lower caudal sternopleural bristle weakly developed *fusca* n. sp.
- Scutellum uniformly grayish on lateral and ventral surfaces; lower caudal sternopleural bristle stoutly developed *annexa* n. sp.
4. Tibiæ, parafacials and cheeks normally largely reddish; arista hairs longer than basal diameter of arista; prealar bristle absent; cross veins cloudy; cruciate setulæ present *johnsoni* (Stein)
- Tibiæ normally largely blackish; arista minutely pubescent or bare; cross veins clear 5
5. Mid tibia with a bristle on anteroventral surface; fore tibia with a robust apical posterodorsal bristle; cruciate setulæ present.
unilineata (Zett.)
- Mid tibia with a bristle on mid ventral surface; fore tibia lacks a robust apical posterodorsal bristle; cruciates absent 6
6. Prealar bristle as long as posterior notopleural bristle; planes of dorsocentral and acrostical bristles usually noticeably setulose; abdominal vitta blackish *obtusa* (Zett.)
- Prealar bristle shorter than posterior notopleural bristle, or absent; planes of dorsocentral and acrostical bristles not noticeably setulose; abdominal vitta brownish *unistriata* (Zett.)
7. Prealar bristle present 8
- Prealar bristle usually absent 11
8. Notopleural callosity with several setulæ; parafacials broader ventrad than at base of antennæ; proboscis slender *annexa* n. sp.
- Notopleural callosity invariably devoid of setulæ; parafacials broader at base of antennæ and narrower ventrad; proboscis not slender 9
9. Processes with a fringelike series of long bristles from base to apex that is ventrally directed; prealar bristle short *maculata* (Stein)
- Processes with no pronounced series of longish bristles directed ventrad, if long directed caudad; prealar bristle as long as posterior notopleural bristle 10
10. Bristles on inner border of processes short and stiffish, stouter developed than bristles on outer border (fig. 13); bristles on antero- and posteroventral surfaces of hind femur not longer than greatest breadth of femur *albiseta* (von Roser)
- Bristles on inner border of processes fine and slender, not stouter developed than those on outer border (fig. 15); bristles on antero- and posteroventral surfaces of hind femur longer than greatest breadth of femur *sociata* (Meigen)
11. Arista hairs longer than basal diameter of arista; tibiæ reddish tinged; processes with no noticeable series of bristles directed ventrad 12

- Arista hairs not longer than basal diameter of arista; tibiae black; processes with a noticeable series of downwardly directed bristles. *maculata* (Stein)
- 12. Processes reddish yellow; mid tibia with apical anterodorsal bristle more robust than apical posterodorsal; *m-cu* cross vein usually cloudy and semierect *johnsoni* (Stein)
- Processes blackish; mid tibia with apical posterodorsal bristle more robust than apical anterodorsal; *m-cu* cross vein clear and usually obliquely directed *marylandica* (Malloch)

KEY TO FEMALES

- 1. Mid tibia with a bristle on anteroventral or mid ventral surface 2
- Mid tibia with no bristle on either ventral surface 7
- 2. Tibiae reddish yellow; cross veins cloudy; arista hairs longer than basal diameter of arista *johnsoni* (Stein)
- Tibiae blackish; cross veins clear; arista hairs not longer than basal diameter of arista 3
- 3. Notopleural callosity with several setulae 4
- Notopleural callosity devoid of setulae 5
- 4. Scutellum fuscous on lateral and ventral surfaces; fore tibia with at least three well developed apical bristles; setulae on mesopleura encroaching cephalad onto declivity dorsad of mesothoracic spiracle *fusca* n. sp.
- Scutellum grayish on lateral and ventral surfaces, concolorous with dorsum; fore tibia with two well developed apical bristles; mesopleural setulae not encroaching onto declivity dorsad of mesothoracic spiracle *annexa* n. sp.
- 5. Fore tibia with a robust apical posterodorsal bristle; mid tibia with bristle on anteroventral surface; cruciate setulae present; outer pair of verticals bristlelike *unilineata* (Zett.)
- Fore tibia lacks a robust apical posterodorsal bristle; mid tibia with bristle on mid ventral surface; cruciates absent; outer pair of verticals setulose 6
- 6. Prealar bristle as long as posterior notopleural bristle; abdominal vitta blackish; first abdominal sternum with several setulae; middle four bristles of marginal series on tergum 5 situated further from caudal margin than those laterad *obtusa* (Zett.)
- Prealar bristle shorter than posterior notopleural bristle, or absent; abdominal vitta brownish; first abdominal sternum bare; middle four bristles of marginal series on tergum 5 situated about the same distance from margin as those laterad *unistriata* (Zett.)
- 7. Prealar bristle present 8
- Prealar bristle usually absent 9
- 8. Palpi flattish, narrowly spatulate; hind femur with a stoutish bristle on posteroventral surface *sociata* (Meigen)
- Palpi slender, filiform; hind femur with no stoutish bristle on posteroventral surface *albiseta* (von Roser)

9. Frons at narrowest about equal to one-third width of head viewed from above; arisal hairs longer than basal diameter of arista; ovipositor armed with recurrent spines on anal palpi *marylandica* (Malloch)
 - Frons less than one-third width of head; arista minutely pubescent; ovipositor lacks recurrent spines on anal palpi (figs. 19, 20).

maculata (Stein)

Leucophora albiseta (von Roser)

- Leucophora cinerea* Robineau-Desvoidy, Essai Myod., 1830 p. 563 . . . Coquillett, Jour. N. Y. Ent. Soc., 1901 IX p. 138
 . . . Coquillett, Proc. U. S. Nat. Mus., 1910 XXXVII p. 560.
Chortophila cinerea Macquart, Hist., Nat. d. Ins., 1835 II p. 328.
Anthomyia albiseta von Roser, Württemb. Corrb., 1840 I p. 59.
Aricia albescens Zetterstedt, Dipt. Scand., 1845 IV p. 1520.
Anthomyia albescens Schiner, Faun. Austr., 1862 I p. 638 . . . Neuhaus, Diptera marchica, 1886 p. 228.
Hammomyia albescens Rondani, Dipt. Ital., Prodr., 1877 VI p. 236 . . . Strobl, Verh. zool.bot. Ges. Wien, 1893 XLIII p. 265 . . . Collin, Trans. Ent. Soc. London, 1921 Pt. III p. 308
 . . . Séguy, Faune de France, 1923 VI p. 71 . . . Karl, Tierwelt Deutschlands, 1928 XIII Pt. 3 p. 191.
Chortophila albescens Meade, Ent. Month. Mag., 1882 XIX p. 146 . . . Meade, Descr. List Brit. Anth., 1897 II p. 44.
Anthomyia (Hammomyia) albescens Pandellé, Rev. Ent. France, 1901 XX p. 300.
Hammomyia albiseta Stein, Kat. Paläark, Dipt., 1907 III p. 698
 . . . Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 1911 XCV Nr. 2 p. 91 . . . Stein, Arch. f. Naturgesch., 1914 (1913) LXXIX A heft 8 p. 32 . . . Stein, Arch. f. Naturgesch., 1916 (1915) LXXXI A heft 10 p. 163
 . . . Tiensuu, Acta Soc. Faun. Flor. Fenn., 1935 LVIII No. 4 p. 14.
Hylephila albiseta Séguy, Gen. Insect., 1937 Fasc. 205 p. 136.
 Records:-
 Alaska, 2♂, Fairbanks, July 1 1921 (J. M. Aldrich).
 British Columbia, 3♂, Nicola, June 27 1923 (C. B. D. Garrett); 1♂, Seton Lake, Lillooet, June 2 1926, 2♂, June 4 1926 (J. McDunnough).
 California, 1♀, Felton, St. Cruz Mts., 300-500 ft., May 15-19 1907, (J. C. Bradley).

Colorado, 1♂, 1♀, Campus of University of Colorado, Boulder, July 1910, (T. D. A. Cockerell).

Idaho, 1♀, Clementsville, July 22 1926 (R. W. Haegele).

Nova Scotia, 1♂, Kentville, Aug. 14 1917.

Oregon, 1♀, Kiger's Island, June 11 1925 (J. Wilcox).

Washington, 3♂, Clarkston, June 12 1930 (J. M. Aldrich)
[U. S. N. M.]

The male of *albiseta* has been commonly characterized as having a plain dove gray color on thorax and whitish dust on frontal regions of head. The above specimen from Nova Scotia is typical in these respects, but those from Alaska and British Columbia possess a much darker aspect and resemble in many ways the allied species *sociata* (Meigen). If it were not for the structure of the copulatory appendages (figs. 1, 12, 13) and for the fact that many of the species represented in this study exhibit a similarly wide range in tonal forms it would be a difficult matter to reconcile the fact that these western specimens represented the same species as the dove gray examples of *albiseta* from Europe. The female of *albiseta* has the palpi filiform, whereas in *sociata* they are narrowly spatulate in this sex.

Leucophora johnsoni (Stein)

Hylemyia johnsoni Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII p. 215 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI p. 552 . . . Britton, Bull. 31 Conn. Geol. Nat. Hist. Surv., 1920 p. 198 . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 234.

Hammomyia johnsoni Stein, Arch. f. Naturgesch., 1919 (1917) LXXXIII A heft 1 p. 152 . . . Stein, Arch. f. Naturgesch., 1920 (1918) LXXXIV A heft 9 p. 84 . . . Malloch, Canad. Ent., 1921 LIII p. 78 . . . Hockett, Mem. 77 N. Y. (Cornell) Agr. Exp. Sta., 1924 (1923) p. 13 . . . Hallock and Parker, Circ. 103 N. J. Dept. Agr., 1926 p. 16.

Hylephila johnsoni Séguéy, Gen. Insect., 1937 Fasc. 205 p. 138.
Records:—

Idaho, 2♂, Mt. Moscow, June 1924 (J. M. Aldrich) [U. S. N. M].

New York, 1♂, Glen Head, Long Island, April 14 1921; 13♂, 1♀, Valley Stream, Long Island, April 27 1921; 3♂, Lake-

ville, Long Island, May 22 1921; 1♀, Babylon, Long Island, May 22 1933, 1♀, June 15 1935 (F. S. Blanton); 3♂, Heckscher State Park, Long Island, May 30 1935, 1♀, Babylon, Long Island, May 24 1934, 1♂, May 22 1935, 1♂, May 26 1935, 1♀, June 9 1934, 1♀, June 15 1934, 1♂, Half Way Hollow Hills, Long Island, May 18 1935 (Blanton & Borders); 4♂, Middle Island, Long Island, May 30 1931; 1♀, Riverhead, Long Island, May 27 1934, 1♂, June 26 1927; 1♂, 1♀, Ithaca, May 28 1922.

Ontario, 1♂, Niagara Glen, June 23 1926, 1♀, June 24 1926 (G. S. Walley).

Quebec, 1♀, Covey Hill, June 15 1927 (G. S. Walley).

Texas, 2♂, College Station, April 13 1935, 2♂, April 18 1935, 1♀, April 10 1932, 1♂, April 21 1936 (R. J. Reinhard).

The typical form of *johnsoni* may be described as possessing yellowish tibiae, cloudy cross veins, longish arisal pubescence, but lacking the prealar bristle. There are however specimens which differ in one or more respects to the above combination of characters. In occasional examples the cross veins may be clear and the presence or absence of prealar bristle difficult to determine on account of the development of setae in this region. In the male type, which is preserved in the collections of the Field Museum of Natural History, the mid tibia possesses a mid ventral bristle. This character is lacking in most of the above male specimens, but is present in the female sex. I have tentatively regarded the two male specimens from Idaho as aberrant forms of this species. In these specimens the fore and mid tibiae are largely blackened, arista apparently subnude, abdomen grayish drab, and aedeagus not conforming in structural details to that of eastern examples of *johnsoni*. The proper status of such specimens may be more confidently determined on the examination of a larger series of specimens from western States.

Leucophora marylandica (Malloch)

Hammomyia marylandica Malloch, Trans. Amer. Ent. Soc., 1920 XLVI p. 185 . . . Malloch, Canad. Ent., 1921 LIII p. 78 . . . Hockett, Mem. 77 N. Y. (Cornell) Agr. Exp. Sta., 1924 (1923) p. 14 . . . Hallock and Parker, Circ. 103 N. J. Dept. Agr., 1926 p. 16.

Hylephila marylandica Johnson, Occ. Pap. Boston Soc. Nat. Hist., No. VII 1925 p. 236 . . . Johnson, Insect. Faun. Biol. Surv. Mt. Desert Region, 1927 p. 211 . . . Séguy, Gen. Insect., 1937 Fasc. 205 p. 138.

Records:—

Alberta, 1♀, Waterton, July 8 1923 (H. L. Seamans).

British Columbia, 1♀, Kaslo, June 18 — (R. P. Currie)
[U. S. N. M.]

Colorado, 1♂, Paonia, July (G. E. Quinter) [U. S. N. M.]

Georgia, 1♂, no data [U. S. N. M.]

Massachusetts, 1♀, Brewster, June 25 1937 (Campau).

Michigan, 1♂, Stevensville, Berrien Co., May 29 1938 (C. W. Sabrosky).

New Jersey, 1♂, Rancocas Park, April 23 1925 (H. C. Hallock); 1♀, Delaware Water Gap, June 21 — (A. T. Slosson).

New York, 2♂, Babylon, Long Island, May 11 1935 (Blanton & Borders); 2♂, Selden, Long Island, May 12 1924; 7♂, Riverhead, Long Island, May 6 1923, 5♂, May 18 1923, 1♂, May 20 1923, 2♂, 1♀, May 27 1923, 1♂, May 29 1923, 3♂, 1♀, May 3 1927, 2♂, May 8 1927, 1♂, May 15 1927, 3♂, 4♀, May 22 1927, 2♂, May 4 1938.

Ontario, 1♂, Low Bush, Lake Abitibi, June 20 1925 (N. K. Bigelow).

Quebec, 1♀, Meach Lake, June 21 1916 (W. T. M. Forbes).

Texas, 2♂, College Station, April 13 1935 (H. J. Reinhard).

The species *marylandica* resembles the european form *Musca grisea* Fallén, from which it may be distinguished by the shorter arisal hairs, and by the absence of a robust apical posterodorsal bristle on fore tibia. Among North American species *marylandica* may be associated with *Hylemyia johnsoni* Stein on account of the longish arisal hairs and absence of prealar bristle, but the female of *marylandica* may be readily separated from that of *johnsoni* owing to the lack of a mid ventral bristle on mid tibia and by the broader frons, the latter being at least as wide as distance between the second pair of dorsocentral bristles. In the male the distinguishing characters can not be so readily defined owing to the marked extent of variation within *johnsoni*.

The male of *marylandica*, in common with the female, invariably possesses a more obliquely directed *m-cu* cross vein that not unusually divides the distal half of vein M_{1+2} into two nearly equal sections; whereas in *johnsoni* the cross vein is usually placed in a more upright position and the penultimate section of M_{1+2} is thereby noticeably shorter than the ultimate.

Leucophora sociata (Meigen)

Anthomyia sociata Meigen, Syst. Besch., 1826 V p. 98.

Hylemyia sociata Neuhaus, Diptera marchica, 1886 p. 224.

Hydrophoria sociata Stein, Kat. Paläark. Dipt., 1907 III p. 687.

Hammomyia gallica Schnabl and Dziedzicki, Abh. K. Leop.-Carol.

Deutsch. Akad. Naturforsch., 1911 XCV Nr. 2 p. 236, 355.

Hammomyia sociata Stein, Arch. f. Naturgesch., 1916 (1915)

LXXXI A heft 10 p. 163 . . . Collin, Trans. Ent. Soc. Lon-

don, 1921 Pt. III p. 309 . . . Séguy, Faune de France, 1923

No. VI p. 72 . . . Karl, Tierwelt Deutschlands, 1928 XIII

Pt. 3 p. 192.

Hylephila sociata Séguy, Gen. Insect., 1937 Fasc. 205 p. 138.

Records:—

Alberta, 1♂, Calgary, July 14 1923 (G. Salt).

British Columbia, 1♀, Oliver, May 30 1923, 1♀, June 3 1923,

1♀, Keremeos, June 27 1923 (C. B. D. Garrett); 1♂, Seton

Lake, Lillooet, June 1 1926, 1♂, June 4 1926 (J. McDun-

nough).

California, 1♀, San Gabriel Canyon, Oct. 21 1929.

Colorado, 1♀, Tennessee Pass, 10240 ft. alt., July 11 — (J.

M. Aldrich) [U. S. N. M.]

Idaho, 1♂, Mt. Moscow, July 12 1924, 2♂, Lake Waha, June

14 1930 (J. M. Aldrich); 2♂, Mts., Moscow, June 25 1920

(R. C. Shannon); 1♂, Emigration Canyon, Aug. 24 1934

(T.) O. Thatcher).

Manitoba, 1♀, Winnipeg, June 22 1927 (H. J. Brodie); 1♀,

Aweme, Oct. 7 1924 (N. Criddle).

Maryland, 1♀, Plummers Island, June 22 1916 (A. K. Fisher).

New Hampshire, 1♂, Franconia, (A. T. Slosson).

Utah, 1♂, Uintah Mts., Tryol Lake, (J. C. Fechner).

Washington, 1♂, Ewan, June 13 1920 (R. C. Shannon); 1♂,

Asotin, April 15 1923, 1♀, May 20 1923 (Virgil Argo); 1♂, Mt. Rainier, Shadow Lake, 6200 ft. alt., July 29 1932, 1♂, July 31 1932; 1♂, Potlatch, May 28 1930 (J. M. Aldrich). [U. S. N. M.].

Wisconsin, 1♀, Fountain City, Buffalo Co., Aug. 12-17 1910.

The species *sociata* may be regarded as allied to *albiseta*, the darker forms of the latter superficially resembling this species. In *sociata* the bristles on antero- and posteroventral surfaces of hind femur are more robust than in *albiseta*, being abnormally stoutly developed in some specimens. There are also specific differences observable in the structure of male copulatory appendages (figs. 4, 9). In the female of *sociata* the palpi are narrowly spatulate, being pointed apicad.

Leucophora maculata (Stein)

Hammomyia maculata Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII p. 229 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 554 . . . Malloch, Trans. Amer. Ent. Soc., 1918 XLIV p. 303 . . . Malloch, Canad. Ent., 1921 LIII p. 78 . . . Stein, Arch. f. Naturgesch., 1919 (1917) LXXXIII A heft 1 p. 152 . . . Stein, Arch. f. Naturgesch., 1920 (1918) LXXXIV A heft 9 p. 84.

Hylephila maculata Séguy, Gen. Insect., 1937 Fasc. 205 p. 138.

Records:—

Alberta, 1♂, Wainwright, June 24 1938 (E. H. Strickland); 2♂, 1♀, Waterton, July 9 1923, 1♂, Lethbridge, July 6 1921 (H. L. Seamans).

British Columbia, 1♂, Lillooet, June 15 1917, 1♂, June 14 1917 (J. D. Tothill); 1♂, Chilcotin, July 26 1920 (E. R. Buckell).

California, 1♂, Corona, March 25 1932, 1♂, Riverside, March 14 1933, 1♂, March 30 1933, 2♂, April 10 1933, 1♂, April 1 1933, 1♂, April 3 1933 (A. J. Basinger).

Colorado 1♂, Florissant, June 19 — (Cockerell) [U. S. N. M.].

Idaho, 3♂, 1♀, Moscow, June 24 1912, 2♂, 1♀, June 16 1910 (U. S. N. M.); 1♂, McCall, June 22 1926, 10525 ft. alt.; 1♀, Fairfield, Aug. 27 1926 (R. W. Haegerle).

Manitoba, 1♀, Balmoral, Aug. 24 1924 (A. J. Hunter).

Montana, 1♀, Missoula, July 13 — (U. S. N. M.).

North Dakota, 1♂, Mandan, June 16 1918 (U. S. N. M.).

Oregon, 2♂, Hood River, no date (Childs).

South Dakota, 1♂, Hot Springs, July 13 1924.

Utah, 1♀, Payson, no date (M. H. Peterson).

Washington, 1♂, Friday Harbor, June 19–26 1909; 2♂, 1♀, Lind, June 11 1919, 1♂, June 16 1919; 1♂, Edwall, July 8 — (J. M. Aldrich) [U. S. N. M.]; 1♂, Ritzville, June 12 1920, 1♀, Lake Paha, June 20 1920, 1♀, Sprague, June 20 1920 (R. C. Shannon); 1♂, 1♀, Toppenish, June 19 1923, 1♀, Mt. Rainier, White River, July 20 1924 (A. L. Melander).

Wyoming, 1♂, Yellowstone Park, Madison Jct., July 27 1923 (A. L. Melander).

The species *maculata* is apparently western in its distribution, and does not occur in New York as previously recorded (Huckett 1924, Leonard 1928). The latter citations are based on a female specimen collected at Ithaca which agrees closely with the female cotype of Stein. Stein's female specimen is, in my opinion, not conspecific with the male cotype, and differs from the females of the above records in having recurrent spines on anal palpi, and in the spatulate form of oral palpi. In the above female specimens the terminal sclerites of the ovipositor have a characteristic padded or cushionlike appearance owing to the enlarged form and dense vestiture of the subanal plate; the recurrent spines are not developed (figs. 19, 20). The male of *maculata* may be distinguished by the notable series of long bristles arising from abdominal processes. The bristles are conspicuous on account of their ventral position. The species covers a wide range in general coloration and development of markings. Occasional specimens may possess a weak prealar bristle and three posterodorsal bristles on hind tibia.

Leucophora unilineata (Zetterstedt)

Anthomyza unilineata Zetterstedt, Ins. Lapp., 1838 p. 675.

Aricia unilineata Zetterstedt, Dipt. Scand., 1845 IV p. 1518.

Anthomyia unilineata Schiner, Faun. Austr., 1862 I p. 638.

Chortophila unilineata Meade, Entom. Month. Mag., 1882 XIX p. 146 . . . Meade, Descr. List Brit. Anth., 1897 II p. 44.

Hylephila unilineata Strobl, Verh. zool.-bot. Ges. Wien, 1893 XLIII p. 265 . . . Stein, Arch. f. Naturgesch., 1920 (1918) LXXXIV A heft 9 p. 84 . . . Collin, Trans. Ent. Soc. London, 1921 (1920) Pt. III p. 311 . . . Séguy, Faune de France, 1923 No. VI p. 77 . . . Séguy, Compt. rend. Congrès Sociétés savantes 1925, 1926 p. 475 . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., 1925 No. VII p. 236 . . . Ringdahl, Ark. f. Zool., 1930, Bd. XXIA No. 20 p. 5 . . . Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskydds., 1931 Nr. 18 p. 18 . . . Séguy, Mem. Acad. Cienc. Exact. Fisico-Quim. Natur. Zarag., 1934 III p. 51 . . . Séguy, Gen. Insect., 1937 Fasc. 205 p. 139.

Hammomyia unilineata Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII p. 230 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 554 . . . Stein, Kat. Paläark. Dipt., 1907 III p. 699 . . . Smith, Ann. Rept. N. J. State Museum 1909, 1910 p. 791 . . . Stein, Arch. f. Naturgesch., 1914 (1913) LXXIX A heft 8 p. 32 . . . Cole and Lovett, Proc. Cal. Acad. Sci., 1921 XI No. 15 p. 313 . . . Leonard, Mem. 101 N. Y. (Cornell) Agr. Exp. Station, 1928 (1926) p. 837 . . . Strickland, Canad. Journ. Research, 1938 Sec. D XVI p. 209.

Anthomyia (Hammomyia) buccata Pandellé not Fallén, Rev. ent. France, 1901 XX p. 301.

Records:—

Alberta, 1♀, Wabamun, April 21 1934, 2♂, 1♀, Edmonton, April 25 1937, 1♂, April 28 1937, 1♀, May 13 1937 (E. H. Strickland); 1♀, same locality, April 30 1937 (F. O. Morrison).

Manitoba, 1♂, Aweme, April 7 1935 (N. Criddle).

Michigan, 1♀, Grand Rapids, May 15 1937.

New York, 1♀, Sea Cliff, Long Island, April (N. Banks) [U. S. N. M.]; 2♀, Valley Stream, Long Island, April 27 1921; 1♂, Deer Park, Long Island, April 20 1935; 1♂, Dix Hills, Long Island, April 18 1935 (Blanton & Borders); 1♂, Riverhead, Long Island, April 28 1924, 1♂, 1♀, May 1 1927; 1♀, May 13 1923, 4♀, May 4 1926, 2♀, May 8 1926, 1♀, Sept. 12 1926; 1♂, Southold, Long Island, April 11 1925; 1♀, Ithaca, May 2 1900.

Wisconsin, 4♀, Madison, April 14 1936, 12♀, April 29 1936, 4♀, May 3 1936, 2♀, May 11 1936, 4♂, 2♀, Dane County, April 18 1937, 4♂, 4♀, May 1 1937, 3♂, 2♀, May 6 1937, 1♂, April 22 1937, 1♀, Devils Lake, May 7 1937 (F. M. Snyder).

The species *unilineata* may be distinguished from related forms in that the mid tibia possesses a weak bristle near middle of anteroventral surface. In both sexes the fore tibia has a robust posterodorsal apical bristle and interfrontalia a pair of weak cruciate setulæ. Collin (1921) has recorded that Stein in his monograph on the European Anthomyiidae appeared to have mistaken *obtusa* for *unilineata*, and that Schnabl and Dziedzicki in *Die Anthomyiden* have erroneously illustrated the copulatory appendages of *unistriata* as belonging to this species. I have also in a study of the Anthomyiinae of New York mistakenly represented the figures of the male genitalia of *obtusa* as belonging to *unilineata*.

Leucophora obtusa (Zetterstedt)

Anthomyza obtusa Zetterstedt, Ins. Lapp., 1838 p. 682.

Aricia obtusa Zetterstedt, Dipt. Scand., 1845 IV p. 1571.

Hylephila obtusa Stein, Arch. f. Naturgesch., 1920 (1918)

LXXXIV A heft 9 p. 84 . . . Collin, Trans. Ent. Soc. London, 1921 Pt. III p. 311 . . . Séguy, Faune de France, 1923 No. VI p. 76 . . . Séguy, Compt. rend. Congrès Sociétés savantes 1925, 1926 p. 475 . . . Johnson, Occ. Pap. Boston Soc. Nat. Hist., 1925 No. VII p. 236 . . . Karl, Tierwelt Deutschlands, 1928 XIII Pt. 3 p. 193 . . . Tiensuu, Acta Soc. Faun. Flor. Fenn., 1935 LVIII No. 4 p. 13 . . . Séguy, Gen. Insect., 1937 Fasc. 205 p. 138.

Hammomyia obtusa Leonard, Mem. 101 N. Y. (Cornell) Agr. Exp. Sta., 1926 (1924) p. 837 . . . Hallock and Parker, Circ. 103 N. J. Dept. Agr., 1926 p. 16.

Records:—

California, 1♀, Los Angeles Co., March (U. S. N. M.); 1♀, Artesia, Febr. 10 1935 (M. W. Stone); 1♂, Santa Cruz, April 1924 (Latta); 1♀, Cazadero, April 12 1918 (J. C. Bradley).

District of Columbia, 2♀, Washington, March 26 — (J. M. Aldrich) [U. S. N. M.].

- Idaho, 2♀, Moscow, May 6 1912 (U. S. N. M.); 1♂, Kendrick, April 1912 (U. S. N. M.).
- Illinois, 1♀, Algonquin (Coq.) [U. S. N. M.]; 1♀, Dubois, April 24 1914.
- Indiana, 2♂, Lafayette, no date, 1♂, May 10 1917, 5♂, 1♀, April 22 1917, 1♂, April 17 1916, 1♀, April 28 1916, 2♀, May 1 1915 (J. M. Aldrich), 1♂, same locality, April 21 1915 [U. S. N. M.].
- Kansas, 1♀, Ellsworth Co., May (R. H. Painter).
- Michigan, 1♂, Detroit, no date (Hubbard & Schwartz) [U. S. N. M.].
- Montana, 1♀, Gallatin Co., 4800 ft. alt., April 26 1902 (R. Benton).
- New York, 1♂, 5♀, Valley Stream, Long Island, April 27 1921; 1♀, Dix Hills, Long Island, May 19 1935, 1♀, Half Way Hollow Hills, Long Island, May 18 1935 (Blanton & Borders); 1♂, Yaphank, Long Island, May 3 1924; 2♂, 1♀, Riverhead, Long Island, May 13 1923, 1♀, May 8 1926; 1♀, Ithaca, no date, 1♀, April 16 1917 (R. C. Shannon); 1♂, Taughanick Falls, near Ithaca, April 21 1917 (R. C. Shannon).
- Ohio, 1♂, Marion, May 1 1915 (R. C. Smith).
- Oregon, 1♂, Kiger's Island, April 8 1930 (J. Wilcox); 1♀, Corvallis, March 27 1919 (A. L. Lovett), 1♀, April 8 1930 (J. Wilcox).
- Pennsylvania, 1♂, Harrisburg, April 1917, 1♀, April 1929 (W. R. Walton); 1♀, Allegheny, no date [U. S. N. M.].
- Quebec, 1♂, Mount Royal, April 12 — (J. Ouellet).
- Texas, 1♂, College Station, March 1 1937 (H. J. Reinhard).
- Utah, 1♂, Spanish Fork, no date (D. E. Hardy); 2♀, Logan Canyon, April 24 1938 (Wm. P. Nye).
- Virginia, 1♀, Great Falls, May 11 1917 (C. T. Greene).
- Washington, 18♂, 3♀, Pullman, May 3 1924, 2♂, 1♀, May 13 1923, 4♂, April 22 1923, 2♂, April 25 1924, 1♀, June 4 1925 (A. L. Melander); 1♀, Rainier National Forest, Sawmill Flat, May 26 1935 (J. Wilcox).
- Wisconsin, 2♂, Madison, May 5 1936, 1♀, May 11 1936, 2♂, April 29, 1936, 4♂, Dane County, May 6 1937, 1♂, May 10 1937, 1♂, Devils Lake, May 7 1937 (F. M. Snyder).

The species *obtusa* has undoubtedly been confused with *unilineata* and *unistriata* (Zetterstedt) in many local collections. Structurally the species resembles *unistriata* (= *paludis* Joh.), but *obtusa* is usually larger and typically is clothed with more abundant setulæ. In the above series of specimens there are few if any safe diagnostic characters that may serve usefully to separate the species from *unistriata*. The more satisfactory distinctions have been presented in the keys to species.

Collin (1921) has concluded that Stein's european records of *obtusa* do not refer to that species but to another for which he has proposed the name *personata*. I have also concluded from an examination of the specimen on which Stein⁹ based his record of *obtusa* in North America that the specimen does not probably belong to that species but is more likely conspecific with the form named herein as *fusca*.

Leucophora unistriata (Zetterstedt)

Anthomyza unistriata Zetterstedt, Ins. Lapp., 1838 p. 677.

Aricia unistriata Zetterstedt, Dipt. Scand., 1845 IV p. 1512.

Hammomyia unistriata Stein, Entom. Nachr., XVIII 1892 p. 325

. . . Stein, Kat. Paläark. Dipt. 1907 III p. 700 . . . Knowlton, Trans. Utah Acad. Sci. Arts Letters, 1936 XIII p. 239

. . . Strickland, Canad. Jour. Res., 1938 D XVI p. 209.

Hammomyia paludis Johannsen, Ent. News, 1917 XXVIII p.

323 . . . Malloch, Canad. Ent., 1921 LIII p. 78 . . . Hockett, Mem. 77 N. Y. (Cornell) Agr. Exp. Sta., 1924 (1923) p. 14.

Hylephila unistriata Collin, Trans. Ent. Soc. London, 1921

(1920) Pt. III p. 319 . . . Séguy, Faune de France, 1923

No. VI p. 77 . . . Séguy, Compt. rend. Congrès Sociétés

savantes 1925, 1926 p. 475 . . . Karl, Tierwelt Deutschlands,

1928 XIII (3) p. 193 . . . Séguy, Gen. Insect., 1937 Fasc.

205 p. 139.

Records:—

Alberta, 2♂, Edmonton, May 10 1924, 1♂, May 9 1937, 3♂, 3♀, May 6 1924, 1♀, May 23 1937 (E. H. Strickland); 1♂, Edmonton, May 11 1938 (A. W. E. Eriksson); 1♀, same locality April 30 1937 (F. O. Morrison); 1♂, Wabamun, May 28 1936 (E. H. Strickland).

⁹ Stein, P. Nordamerikanische Anthomyiden, 2 Beitrag, Arch. f. Naturgesch., 1920 (1918) LXXXIV A heft 9 p. 84.

Indiana, 1♂, Lafayette, April 27 1918 (J. M. Aldrich) [U. S. N. M.].

Michigan, 1♀, Albion, May 16 1936, 1♂, E. Lansing, May 9 1937, 1♀, May 14 1937 (C. W. Sabrosky).

New York, 2♂, 1♀, Valley Stream, Long Island, April 27 1921; 2♀, Babylon, Long Island, May 10 1935 (Blanton & Borders); 1♀, Ithaca, April 30 1915, 1♀, April 25 1920, 1♂, April 29 1922; 1♂, 6-mile Creek, Ithaca, April 29 1922 (L. S. West); 1♂, Cayuta Lake, May 8 1935; 2♀, Danby, May 14 1916 (E. G. Anderson).

Nova Scotia, 1♂, Truro, June 24 1917, 1♀, June 18 1917; 1♂, Kentville, June 27 1917.

Washington, 1♂, Pullman, April 21 1924 (A. L. Melander).

The species comes closest to *obtusa*, but is usually smaller and of paler hue. The *m-cu* cross vein in *unistriata* is quite frequently more upright than in *obtusa*. In some male specimens of *unistriata* the prosternum may possess bristles. The species may usually be distinguished from *obtusa* and other related species by the characters given in the keys.

Collin (1921) is of the opinion that *unistriata* was included by Stein in his later European records under *inflata* Rondani, and that Schnabl and Dzierżicki have mistaken the species for *unilineata* Zett. Johnson¹⁰ and Leonard¹¹ have listed *paludis* Johannsen as a synonym of *obtusa* Zetterstedt. I have seen a female paratype of *paludis* in the collections of the United States National Museum that I regard as conspecific with *obtusa*, but the type specimens of *paludis* are, in my opinion, representative of *unistriata*.

Leucophora fusca new species

Male, parafrontals and parafacials silvery pruinulent, cheeks reddish tinged; antennæ and palpi blackish, proboscis lightly pruinulent; thorax and abdomen with dark reflections, the former subshining and with trace of three brownish vittæ, scutellum infuscated laterad; abdomen more densely pruinulent, abdominal vitta brownish, paler on basal terga. Legs blackish, narrowly reddish at knees. Wings faintly tinged, lower calyptral scale whitish; halteres deep yellow with trace of reddish tinge.

¹⁰ Johnson, C. W. List of the diptera or two-winged flies. 15. Fauna of New England. Occ. Pap. Boston Soc. Nat. Hist., 1925 VII p. 236.

¹¹ Leonard, M. D. A list of the insects of New York. Mem. 101 N. Y. (Cornell) Agr. Exp. Sta., 1928 (1926) p. 837.

Frons at narrowest scarcely wider than breadth of third antennal segment, frontal bristles continued to ocellar callosity, cruciate setulæ present; buccal region strongly developed, parafacials wider ventrad, lower half of occipital region swollen, marginal bristles and vibrissæ not robust; arista subnude, proboscis slender; thorax with one or more pairs of presutural acrostical bristles, prealar bristle longish, notopleural callosity with setulæ, mesopleural setulæ invading the declivity dorsad of mesothoracic spiracle, scutellum setulose laterad, ventral bristle of caudal pair of sternopleurals weakly developed; abdomen stout, truncated, scarcely as long as thorax, processes short and blunt, sterna clothed with longish bristles, tergal marks slightly tapering toward caudal margin.

Fore tibia with two or more posteroventral bristles, apical anterodorsal robust, apical posterodorsal weak; mid tibia with a mid ventral bristle, one anterodorsal, one posterodorsal and two or more bristles on posterior surface, apical anterodorsal robust, apical posterodorsal weak; hind femur with a complete series of anteroventral bristles with a series of finer bristles on proximal half of posteroventral surface; hind tibia with three to five anteroventral bristles, four or five anterodorsal, three posterodorsal, four or five weaker posteroventral bristles. Wings with *m-cu* cross vein sinuate and markedly oblique; cell R_{5+6} slightly narrower distad. Length 9 mm.

Female similar to male, paler, width of frons as in male, marginal bristles of fifth abdominal tergum stoutly developed, ovipositor with a pair of short recurrent spines and numerous spinules on anal palpi. Fore tibia with a mid posterior and a weak anterodorsal bristle; mid tibia with a posteroventral bristle adjacent mid ventral bristle; hind femur with bristles on proximal half of antero- and posteroventral surfaces weaker, hind tibia with a series of three or more weak bristles on posteroventral surface.

Type, ♂ Mt. Moscow, Idaho, June 5 1930 (J. M. Aldrich) [U. S. N. M.].

Allotype, ♀ Lafayette, Indiana, May 14 1918 [U. S. N. M.].

Paratypes, ♂ Edmonton, Alberta, May 9 1937, ♀, Clymont, Alberta, May 24 1937 (E. H. Strickland) [C. N. C.].

Records:

Alberta, 1♂, Edmonton, May 13 1937 (F. O. Morrison).

Idaho, 7♂, Mt. Moscow, June 5 1930 (J. M. Aldrich) [U. S. N. M.].

Indiana, 1♂, Lafayette, April 26 — (U. S. N. M.), 2♀, same locality, May 14 1918 (U. S. N. M.).

Oregon, 1♂, Corvallis, June 2 1929 (John Wieting).

Washington, 4♂, Almota, May 20 1923 (A. L. Melander); 1♀, Sprague, June 13 1920, 1♀, Ewan, June 13 1920 (R. C. Shannon).

The species *fusca* resembles the European form *personata* Collin, from which it may be distinguished by the scutellar infuscation, weakly developed ventral bristle of caudal pair of sternopleurals, and by the presence of weak cruciate setulæ. This is the species recorded by me in error as *personata* in Strickland's list¹² of the dipterous flies occurring in Alberta. Another closely allied species is described as follows.

***Leucophora annexa* new species**

Male and female resembling *fusca*, differing in that the mesonotum has only a dorsocentral vitta, scutellum entirely pale grayish. In the male the lower sternopleural bristle of caudal pair is well developed and the processes are longer. Fore tibia with one or two posteroventral bristles, apical anterodorsal weak, mid tibia with a weak mid ventral bristle, hind femur with bristles on proximal half of posteroventral surface weaker and shorter, not as long as breadth of hind femur where situated, hind tibia with a weaker series of posteroventral bristles. In the female the lower sternopleural bristle of caudal pair is weakly developed, fore tibia lacks a mid posterior bristle as in *fusca* and has a weakly developed apical anterodorsal, apical posteroventral absent, mid tibia with a stout mid ventral bristle, one anterodorsal, one posterodorsal and three posterior bristles, apical anterodorsal robust, hind femur with no series of bristles on posteroventral surface, hind tibia with one or two inconspicuous longer setulæ on posteroventral surface.

Type, ♂, Lind, Washington, May 30 1919 (F. W. Carlson); Allotype, ♀, Lewiston Hill, Idaho, May 31 1934 (A. L. Melander). In the collection of Dr. A. L. Melander.

Superficially *annexa* resembles a paler form of *fusca*, and in this respect conforms closely to the appearance of *personata* Collin. I have regarded the species as distinct from *personata* owing to the presence of cruciate setulæ, weaker series or lack of bristles on posteroventral surface of hind femur, and further owing to the greater length of abdominal processes in male. Since the mid ventral bristle on mid tibia of male is notably weak in the specimens examined I have included the species under both categories in the first couplet of the male key, lest additional specimens may show that this character is not dependable for comparative purposes.

¹² Strickland, E. H. An annotated list of the diptera (flies) of Alberta. Canad. Journ. Research, Sec. D XVI 1938 p. 209.

Genus *Proboscimyia* Bigot

- Proboscimyia* Bigot, Bull. Soc. Ent. France, 1883 No. 4 p. 30 . . .
 Hockett, Mem. 77 N. Y. (Cornell) Agr. Exp. Station, 1924
 (1923) p. 50 . . . Curran, Fam. Gen. N. A. Dipt., 1937 p.
 391.
- Proboscidomyia* Bigot, Ann. Soc. Ent. France, 1884 ser. 6 IV p.
 266 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No.
 1444 p. 548 . . . Stein, Arch. f. Naturgesch., 1919 (1917)
 LXXXIII A heft 1 p. 152 . . . Séguéy, Gen. Insect., 1937
 Fasc. 205 p. 128.
- Dolichoglossa* Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII p.
 230 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No.
 1444 p. 554 . . . Williston, Man. N. A. Dipt., 1908 3rd ed.,
 p. 335.

Genotype *Proboscimyia siphonina* Bigot.

The genus is not to be readily distinguished from *Leucophora* as denoted by the adult flies. Nothing, as far as I am aware, is known concerning the habits of the species. The character that has served to distinguish the group has been the abnormally slender proboscis in the genotype. It is to me doubtful whether this character is of generic value in view of the fact that another species belonging to the genus occurs in North America whose proboscis is not abnormally slender. The lower calyptra in both species is protruded distinctly beyond margin of upper scale.

KEY TO SPECIES

- Distal section of proboscis longer than fore tarsus, oral vibrissæ shorter than palpi *siphonina* Bigot
 Distal section of proboscis not as long as fore tarsus, oral vibrissæ as long as or longer than palpi *brevis* n. sp.

Proboscimyia siphonina Bigot

- Proboscimyia siphonina* Bigot, Bull. Soc. Ent. France, 1883 No. 4 p. 30.
- Proboscidomyia siphonina* Bigot, Ann. Soc. Ent. France, 1885 ser. 6 V p. 267 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 548 . . . Stein, Arch. f. Naturgesch., 1919 (1917) LXXXIII A heft 1 p. 152 . . . Séguéy, Gen. Insect., 1937 Fasc. 205 p. 129.

Dolichoglossa americana Stein, Berl. Ent. Zeitschr., 1898 (1897) XLII p. 230, 286 . . . Aldrich, Misc. Coll. Smithsn. Inst., 1905 XLVI No. 1444 p. 554.

Records:—

Illinois, 1♂, 1♀, Carlinville (Robertson) [U. S. N. M.].

New Mexico, 1♂, Koehler, Aug. 12 1914, 1♂, no date (W. R. Walton), 2♀, Socorro, 1916 (Williston) [U. S. N. M.].

South Dakota, 1♀, Elmira (J. M. Aldrich), cotype of *Dolichoglossa americana* Stein, Lectotype [U. S. N. M.]; 1♀, Onida, July 12 1932 (G. B. Spawen).

Texas, 1♂, Comanche Co., June 8 1928 (V. A. Lityle); 1♀, Taylor, May 27 1929, 1♂, 1♀, Hidalgo Co., June 6 1930 (J. C. Gaines); 1♀, Bexar Co., June 8 1928, 1♂, 1♀, same locality, May 29 1932 (H. B. Parks); 1♂, College Station, May 25 1930, 1♀, same locality, May 29 1920 (H. J. Reinhard) [Texas A. & M.]; 2♀, no data, 1♂, Belfrage [U. S. N. M.].

All previous records have been credited to this species. I am however doubtful whether those of eastern regions may be unreservedly accepted as correct in view of the evidence provided by the material before me. The species *siphonina* is represented exclusively by specimens collected in western parts of North America, whilst in New York, Nova Scotia and the District of Columbia another species has made its appearance.

In *siphonina* the proboscis is much longer, oral vibrissæ weaker, palpi slightly longer and notopleural callosity typically more setulose than in the following species. In both forms the male lacks and the female possesses a mid ventral bristle on mid tibia. In the male of *siphonina* the processes have a chitinous callosity at middle of inner margin (fig. 25).

***Proboscimyia brevis* new species**

Similar to *siphonina* Bigot, but having the parafrontal bristles and oral vibrissæ more robust; proboscis shorter, distal section scarcely as long as fore tarsus; palpi proportionately shorter; mesonotum with fewer accessory setulæ on notopleural callosity; notably so at basal region of posterior notopleural bristle; abdominal processes devoid of a chitinous callosity at middle of inner margin; bristling of legs in male as follows:—Fore tibia with one or two posteroventral bristles and a weak mid anterodorsal bristle; mid tibia with one anterodorsal, one posterodorsal and two posterior bristles; hind

femur with a complete series of anteroventral bristles and a weaker series of bristles on proximal half of posteroventral surface; hind tibia with two anteroventral, three anterodorsal and three posterodorsal bristles.

Female similar to male, with a series of fine recurrent spines on anal palpi of ovipositor; sternopleural bristles arranged 2:2, the lower bristles weakly developed; mid tibia with a strong anterodorsal and mid ventral bristle, hind femur with bristles on anteroventral surface much weaker proximad and those on posteroventral surface absent except for one at base, hind tibia with one or more weak bristles on posteroventral surface. Length, 6-8.5 mm.

Type and allotype, ♂ ♀, Babylon, Long Island, New York, Sept. 18 1937 (F. S. Blanton) [U. S. N. M.].

Records:—

District of Columbia, 1♀, Oct. (Coquillett) [U. S. N. M.].

New York, 1♂, 1♀, Babylon, Long Island, Sept. 14 1933, 1♀, Aug. 15 1933, 1♂, 1♀, Sept. 12 1933, 1♂, Sept. 15 1937, 1♀, Sept. 23 1935, 1♀, Sept. 19 1935, 5♂, 1♀, Sept. 23 1933, 6♂, 4♀, Sept. 18 1937 (F. S. Blanton); 1♂, 1♀, Babylon, Long Island, Sept. 14 1935, 2♂, 1♀, Sept. 19 1934, 4♂, Sept. 12 1935, 1♂, Sept. 17 1935, 2♂, 1♀, Sept. 10 1935, 1♀, Sept. 7 1935 (Blanton & Borders); 1♀, Riverhead, Long Island, Sept. 21 1926.

Nova Scotia, 1♀, Truro, Sept. 15 1913 (R. Matheson).

PLATE XVII

Dorsal or caudal aspect of male copulatory appendages

Figure 1. *Leucophora albiseta* (von Roser).

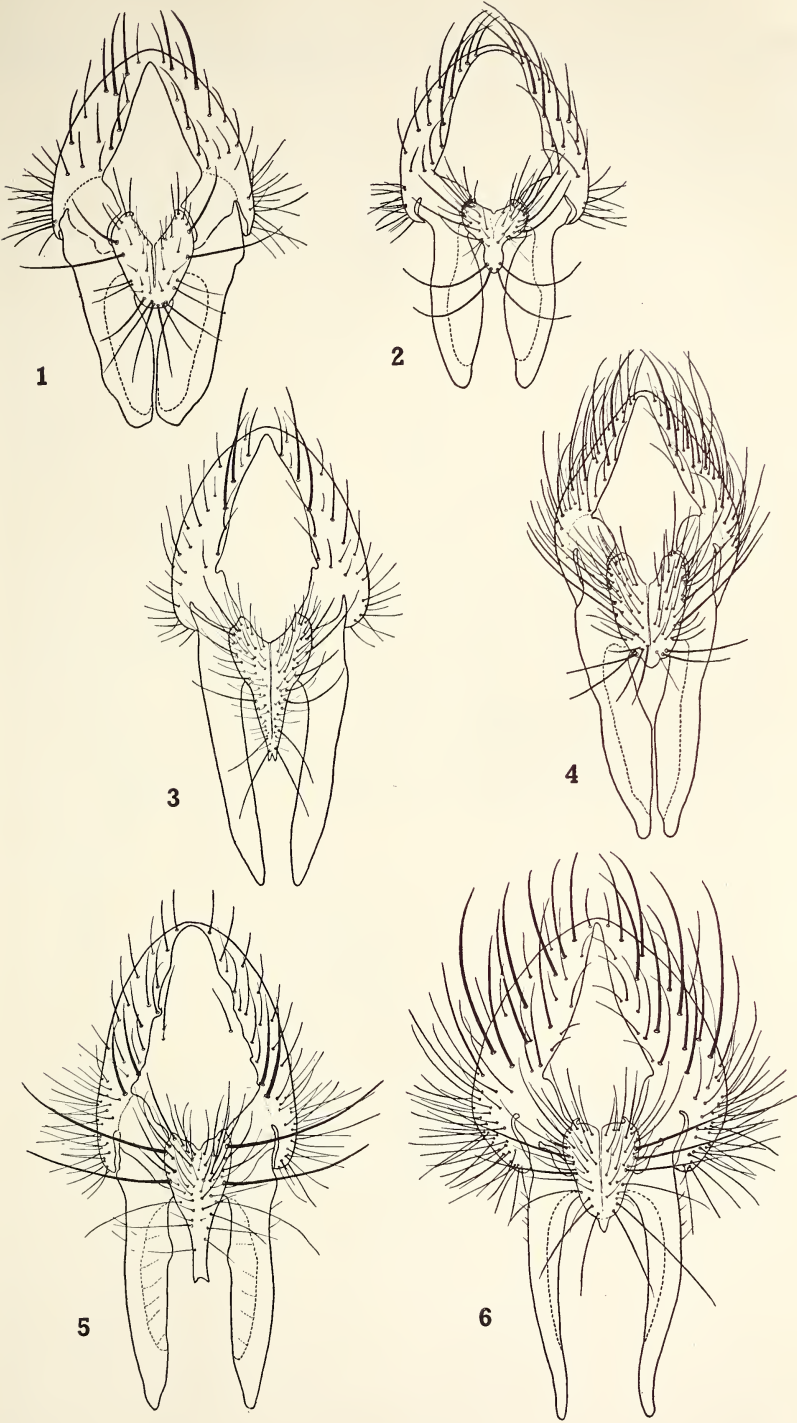
Figure 2. *Leucophora maculata* (Stein).

Figure 3. *Leucophora marylandica* (Malloch).

Figure 4. *Leucophora sociata* (Meigen).

Figure 5. *Leucophora fusca* new species.

Figure 6. *Leucophora unilineata* (Zetterstedt).

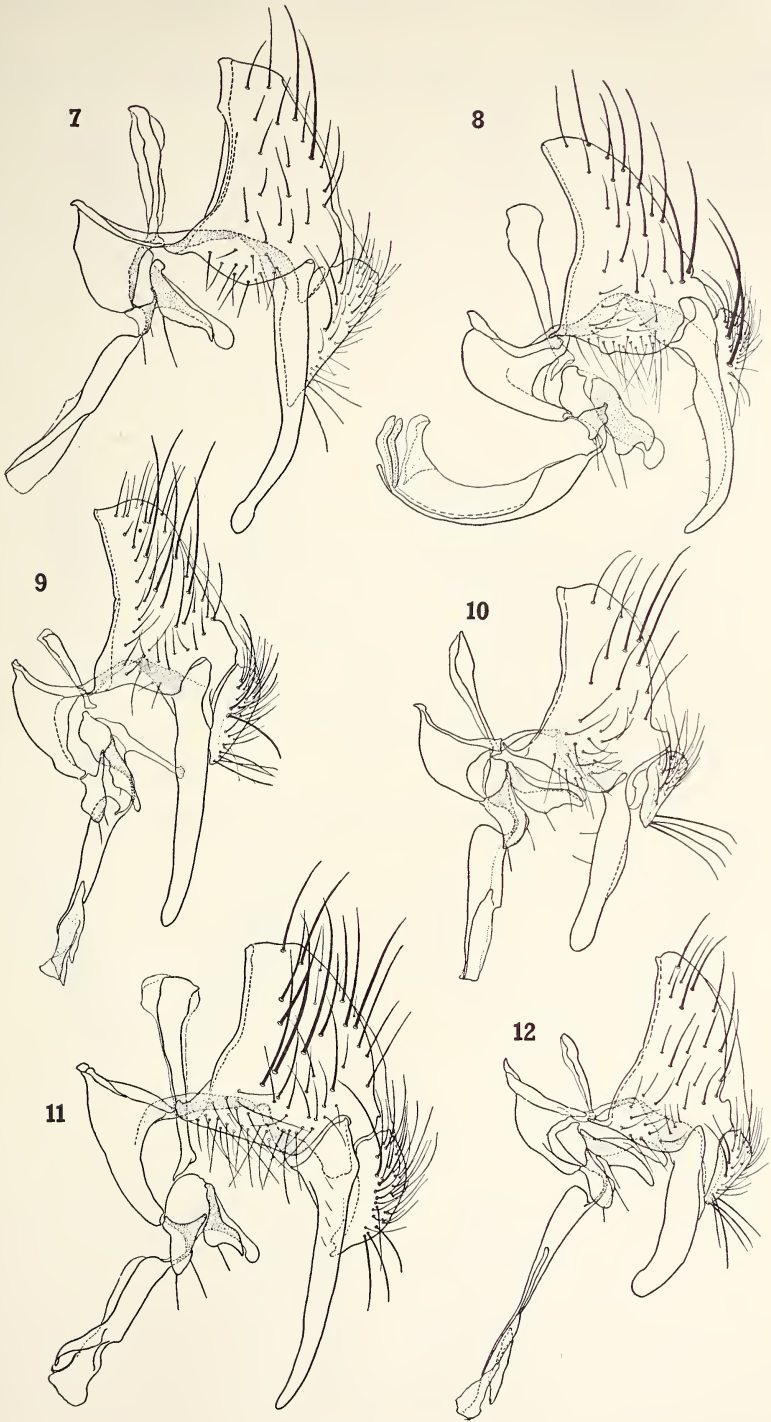


LEUCOPHORA

PLATE XVIII

Lateral aspect of male copulatory appendages

- Figure 7. *Leucophora marylandica* (Malloch).
Figure 8. *Leucophora fusca* new species.
Figure 9. *Leucophora sociata* (Meigen).
Figure 10. *Leucophora maculata* (Stein).
Figure 11. *Leucophora unilineata* (Zetterstedt).
Figure 12. *Leucophora albiseta* (von Roser).



LEUCOPHORA

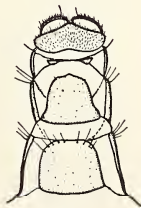
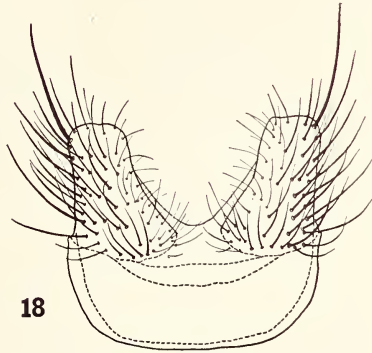
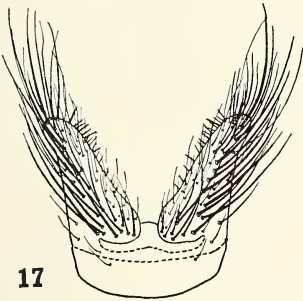
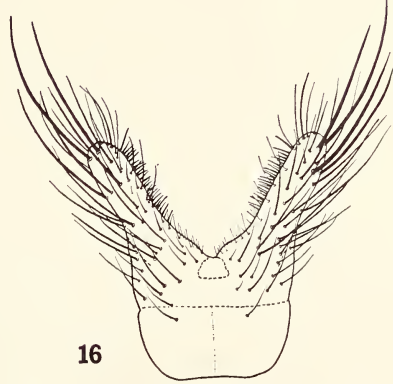
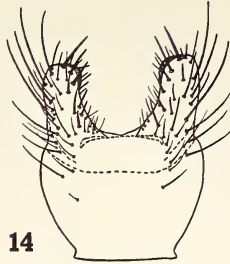
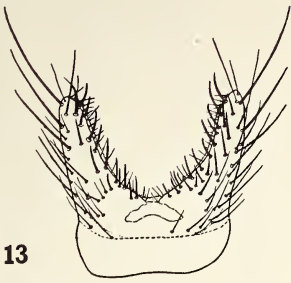
PLATE XIX

Ventral aspect of fifth abdominal sternum in male

- Figure 13. *Leucophora albiseta* (von Roser).
Figure 14. *Leucophora marylandica* (Malloch).
Figure 15. *Leucophora sociata* (Meigen).
Figure 16. *Leucophora unilineata* (Zetterstedt).
Figure 17. *Leucophora maculata* (Stein).
Figure 18. *Leucophora fusca* new species.

Ovipositor of *Leucophora maculata* (Stein)

- Figure 19. Ventral aspect.
Figure 20. Dorsal aspect.



19

20

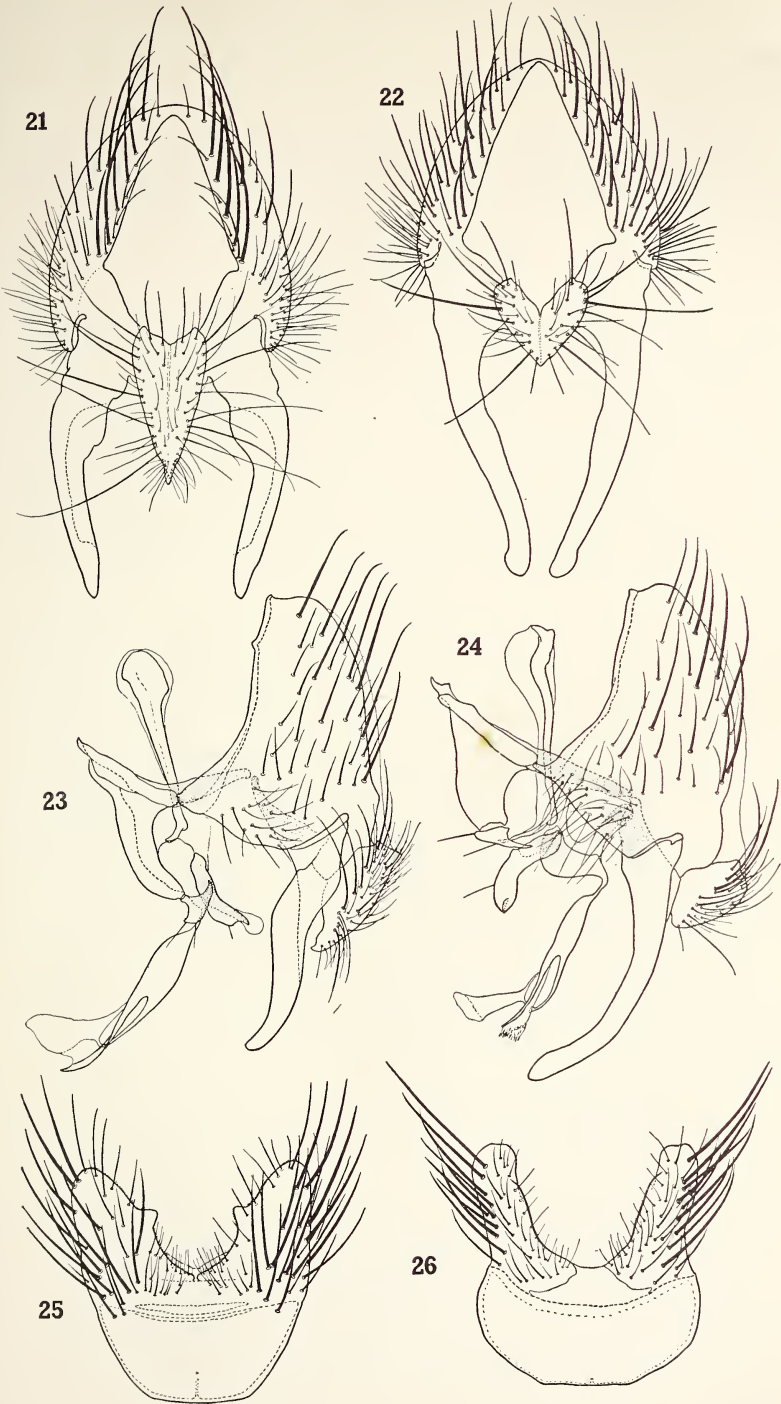
LEUCOPHORA

PLATE XX

Male copulatory appendages of *Proboscimyia*

Figures 21, 23, 25. *Proboscimyia siphonina* Bigot.

Figures 22, 24, 26. *Proboscimyia brevis* new species.



LEUCOPHORA

A RECLASSIFICATION OF THE TRIBE OBRIINI OF LECONTE (COLEOPTERA, CERAMBYCIDÆ)

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The genera treated below were grouped together by LeConte (1873) under the tribal name Obriini. The same arrangement was maintained by LeConte and Horn (1883) and Leng (1886). Recent workers have usually divided the genera into two widely separated tribes and in some cases this has resulted in the placing of very closely related genera in different groups. In the writer's opinion the complex relationships of these genera can best be expressed by the recognition of several tribes as follows:

KEY TO TRIBES

1. Elytra entire, neither abbreviated nor attenuated 2
 Elytra either greatly abbreviated or attenuated 4
2. Anterior coxal cavities closed posteriorly; mesosternum with intercoxal process parallel-sided; pronotum with sides angulate or tuberculate; second segment of antennæ much less than one-half as long as third; abdomen of female with first sternite as long as remaining segments together, sternites 2-5 greatly modified; ultimate segment of palpi cylindrical 3
 Anterior coxal cavities open posteriorly; mesosternum with intercoxal process triangular; pronotum with sides rounded; second segment of antennæ one-half as long as third; abdomen of female with first segment shorter than remaining together, sternites 2-5 unmodified; ultimate segment of palpi dilated Eumichthini
3. Anterior coxæ conical, exserted, nearly contiguous, cavities not angulated externally; intermediate coxal cavities not open to epimera; episterna of metathorax divided by a longitudinal furrow; pronotum without dorsal tubercles Obriini
 Anterior coxæ globular, separated, cavities angulated externally; intermediate coxal cavities open to epimera; episterna of metathorax without a longitudinal furrow; pronotum with dorsal tubercles. Hyboderini
4. Anterior coxal cavities open posteriorly; elytra less than one-half as long as abdomen, apices rounded or truncate, never attenuated or subulate; intercoxal process of mesosternum narrow, triangular, truncate behind; antennæ longer than the body in the male; posterior wings without a post-cubital vein Molorchini
 Anterior coxal cavities closed posteriorly; elytra more than one-half as

long as abdomen, apices attenuated, subulate; intercoxal process of mesosternum broad, flat, emarginate behind; antennæ shorter than the body in both sexes; posterior wings with a single postcubital vein.

Stenopterini

Tribe **Eumichthini** Linsley, new tribe

Head short; eyes finely granulated, deeply emarginate; antennæ with second segment elongate, about one-half as long as third segment; palpi short, last segment triangularly dilated; ligula membranous. Pronotum rounded at sides, without lateral tubercles, dorsal callosities, if present, feeble; anterior coxæ globular, cavities angulate externally, open posteriorly; intermediate coxal cavities open to epimera, intercoxal process triangular; posterior wings with a single post-cubital vein; legs moderate in length, femora clavate, tibial spurs short. Abdomen of female with first sternite shorter than the following segments together, sternites two to five unmodified.

This tribe is necessary for two genera which, in the absence of females, were placed in the Oabriini by LeConte and Horn. In the Aurivillius (1912) and Leng (1920) catalogues one of the genera, *Eumichthus*, is listed in the Oabriini, the other, *Poecilobrium*, in the Molorchini. They appear to me to be equally out of place in either tribe. From the Oabriini they differ in the shape and structure of the anterior coxæ and their cavities, the form of the intercoxal process of the mesosternum, the elongated second segment of the antennæ, the dilated palpi, and the entire, unmodified abdomen of the female. From the Molorchini they may be distinguished by the entire elytra, less prominent and more globular anterior coxæ, elongate second segment of the antennæ, laterally rounded pronotum, distinct stridulatory area of the metanotum, and dilated palpi.

Two genera occur in North America. They may be separated as follows:

- | | |
|--|---------------------|
| Third segment of antennæ shorter than fourth; last segment of palpi narrowly triangular; first two segments of anterior tarsi tumid in male; integument non-metallic | <i>Eumichthus</i> |
| Third segment of antennæ longer than fourth; last segment of palpi broadly triangular; first two segments of anterior tarsi slender in both sexes; integument metallic | <i>Poecilobrium</i> |

Genus *Eumichthus* LeConte

Eumichthus LeConte, 1873, Smithson. Misc. Coll., XI, 264: 190, 265: 305; LeConte and Horn, 1883, Smithson. Misc. Coll., XXVI, 507: 291; Leng, 1886, Entom. Amer., 2: 27.

Eumichtus, Aurivillius, 1912, Coleopt. Catal., **31**: 138.

Integument dull. Head with front declivous; antennæ slightly longer than the body in the male, third segment not longer than fourth segment; antennal tubercles scarcely elevated, intervening area convex; clypeus with a small impression on each side at base; palpi with last segment narrowly triangular. Pronotum without any dorsal callosities; elytra maculate; legs moderately short, femora very strongly clubbed, anterior tarsi of male with first two segments swollen, of female slender.

Genotype: *Eumichthus ædipus* LeConte (by single reference).

The type and only known species of this genus occurs on the Pacific coast of North America. It bears a strong superficial resemblance to the unrelated *Phymatodes decussatus* (LeConte).

Genus *Pœcilobrium* Horn

Pœcilobrium Horn, 1883, Smithson. Misc. Coll. XXVI, 507: 291;

Horn, 1883, Trans. Am. Ent. Soc., **10**: xi; Leng, 1886, Entom. Amer., **2**: 27.

Callimus, LeConte, 1873, Smithson. Misc. Coll., XI, **265**: 305.

Integument shining, metallic. Head with front subvertical; antennæ shorter than the body in both sexes, third segment longer than fourth segment; antennal tubercles slightly elevated, intervening area feebly concave; clypeus with a large impression on each side at base; palpi with last segment broadly triangular. Pronotum with feeble dorsal callosities; elytra concolorous; legs short, femora moderately strongly clubbed; anterior tarsi with first two segments slender in both sexes.

Genotype: *Callimus chalybeus* LeConte (by single reference).

This monotypic genus is based on a small, brilliant, metallic-blue species which occurs along the Pacific coast of North America.

Tribe Obriini Thomson

C. G. Thomson, 1859, Skand. Coleopt., **1**: 150, *Obriina*.

C. G. Thomson, 1866, Skand. Coleopt., **8**: 40, *Obriina*.

Lacordaire, 1869, Genera Coleopt., **8**: 360, *Obrionides*.

Pascoe, 1869, Trans. Ent. Soc. Lond., **1869**: 550.

LeConte, 1873, Smithson. Misc. Coll., XI, **265**: 305, *Obria*.

LeConte and Horn, 1883, *Smithson. Misc. Coll.*, XXVI, 507: 290, *Obria*.

Leng, 1886, *Entom. Amer.*, 2: 27.

Gahan, 1906, *Fauna Brit. India, Coleopt.*, 1: 164.

Blatchley, 1910, *Coleopt. Indiana*, p. 1027.

Plavilstshikov, 1932, *Best.-Tab. eur. Coleopt.*, 102: 62, *Obrina*.

Gressitt, 1935, *Ins. Matsumurana*, 9: 146.

Gressitt, 1939, *Ling. Sci. Jour.*, 18: 10.

Head moderately short; eyes large, coarsely granulated, deeply emarginate; antennæ with second segment short, very much less than one-half as long as third segment; palpi unequal, last segment cylindrical; ligula membranous. Pronotum with sides protuberant or tuberculate; anterior coxæ conical, exserted, nearly contiguous, cavities rounded externally, closed posteriorly; intermediate coxal cavities not open to epimera, intercoxal process parallel-sided; metepisterna with a longitudinal furrow; wings with two post-cubital veins; legs moderately long, femora clavate and pedunculate. Abdomen with first sternite very long in both sexes; first sternite of female as long as following segments together, second sternite deeply emarginate, densely clothed with long, recurved hairs, third sternite very short, fourth and fifth sternites longer.

The outstanding characters of this tribe are the conical, exserted anterior coxæ with their cavities rounded externally and closed behind, the closed intermediate coxal cavities, and the coarsely granulate eyes. This latter character is slightly variable in *Obrium* and in the Philippine and Formosan genus *Pseudiphra*, the eyes are said to be finely faceted.

Genus *Obrium* Dejean

Obrium Dejean, 1821, *Catal. Coleopt.*, ed. I, 110; Curtis, 1825, *British Ent.*, 2: 91; Latreille, 1829, in: Cuvier, *Regne Animal*, 5: 119; Serville, 1834, *Ann. Soc. Ent. France*, 3: 93; LeConte, 1850, *Jour. Acad. Nat. Sci. Phila.*, (2), 2: 21; C. G. Thomson, 1859, *Skand. Coleopt.*, 1: 151; Fairmaire, 1864, *Genera Coleopt. Eur.*, 4: 179; J. Thomson, 1864, *Systema Ceramb.*, 440; C. G. Thomson, 1886, *Skand. Coleopt.* 8: 41; LeConte, 1873, *Smithson. Misc. Coll.*, XI, 265: 306; LeConte and Horn,

1883, *Smithson. Misc. Coll.*, XXII, 507: 291; Leng, 1886, *Ent. Amer.*, 2: 27; Gahan, 1906, *Fauna Brit. India*, *Coleopt.*, 1: 165; Blatchley, 1910, *Coleopt. Indiana*, p. 1027; Reitter, 1912, *Fauna Germ. Käfer*, 4: 29; Planet, 1924, *Encycl. Ent.*, A, 2: 137; Portevin, 1927, *Encycl. Ent.* 2 (suppl.): 22; Scheerpeltz, 1930, *Tierw. Mitteleur. Käfer*, 5: (2): 209; Matshita, 1933, *Jour. Fac. Agr., Hokkaido Univ.*, 34: 305; Gressitt, 1935, *Ins. Matsumurana*, 9: 145.

Head with front sloping anteriorly; antennæ usually at least one-third longer than the body in male, barely longer than body in female, segments three and four subequal in length, basal segments without long, apical hairs; clypeus with a deep, arcuate impression above; palpi short. Pronotum longer than broad, constricted near base, narrowly so before apex; elytra parallel-sided or slightly widened posteriorly, apex broadly rounded; legs elongate, first segment of posterior tarsi as long as following two together.

Genotype: *Cerambyx cantharinum* Linnaeus (Curtis designation, 1825).

This genus reaches its greatest development in America but is well represented in the Old World. *Phyton* Newman cannot be separated on the basis of the characters used in the literature, but it is possible that a careful study, in the light of the neotropical fauna, may reveal other characters of generic or subgeneric importance.

Tribe **Hyboderini** Linsley, new tribe

Head moderately short; eyes finely granulated; antennæ with second segment short, much less than one-half as long as third segment; palpi unequal, last segment cylindrical; ligula membranous. Pronotum with sides and disk tuberculate; anterior coxæ globular, separated, cavities angulated externally, open behind; intermediate coxal cavities open to epimera, intercoxal process parallel-sided; metepisterna without a longitudinal furrow; wings with a single post-cubital vein (two in *Megobrium*); legs moderately long, clavate. Abdomen with first sternite elongate in both sexes; first sternite of female as long as following segments together, second sternite deeply emarginate, densely hairy, third sternite very short, fourth and fifth sternites longer.

This tribe is related to the O布里尼 with which it agrees in the structure of the female abdomen. It differs markedly, however, in the finely granulate eyes, globular anterior coxæ with

their cavities widely angulated externally, open intermediate coxal cavities, etc. Recent workers have placed the genera in the Molorchini, a group from which they differ in the entire elytra, the modified abdomen of the female, the parallel-sided mesosternal process, and the presence of at least one post-cubital vein in the wing. The North American genera differ as follows:

1. Pubescence sparse, depressed hairs few, flying hairs numerous; punctation coarse 2
- Pubescence short, dense, appressed, flying hairs absent; punctation fine. *Hybodera*
2. Intermediate coxæ separated by at least their own diameters; metepisterna broad, parallel-sided; elytral punctures coarse, distinct throughout, elytral apices dehiscent, inner angle acute; posterior tibiæ arcuate. *Lampropterus*
- Intermediate coxæ separated by much less than their own diameters; metepisterna attenuated apically; elytral punctures becoming obsolete over apical one-third, apices separately rounded; posterior tibiæ straight... 3
3. Anterior coxæ distinctly separated; intercoxal process of mesosternum less than twice as wide as that of prosternum; antennæ of male distinctly shorter than body *Pseudopilema*
- Anterior coxæ narrowly separated; intercoxal process of mesosternum several times as wide as that of prosternum; antennæ of male distinctly longer than body *Megobrium*

Genus *Hybodera* LeConte

Hybodera LeConte, 1873, *Smithson. Misc. Coll.*, XI, **264**: 191, **265**: 306; LeConte and Horn, 1883, *Smithson. Misc. Coll.*, XXVI, **507**: 291; Leng, 1886, *Entom. Amer.*, **2**: 27.

Pubescence short, dense, appressed, without an intermixture of flying hairs; punctation fine. Head with front short, declivous; vertex canaliculate; basal suture of clypeus deeply impressed; eyes deeply emarginate; antennæ longer than the body in the male, shorter than body in female; palpi short, last segment slightly oval. Pronotum a little longer than broad, strongly constricted anteriorly, less so posteriorly, sides obtusely angulate, disk quadrituberculate; prosternum distinctly separating coxæ; intercoxal process of mesosternum broad, truncate; metepisterna attenuated apically; elytra somewhat flattened, parallel-sided, apex rounded; legs with femora strongly clavate, posterior tibiæ straight; first segment of posterior tarsi longer than following two together.

Genotype: *Hybodera tuberculata* LeConte (by single reference).

Only two species are known in this remarkable genus. Both are confined to the Pacific coast of North America.

Genus *Lampropterus* Mulsant

Lampropterus Mulsant, 1863, Coleopt. France, Longie., Ed. 2, 214.

Callimus Mulsant, 1846, Coleopt. France, 4, Append; Thomson, 1860, Class Ceramb., p. 160; Thomson, 1864, Systema Ceramb., p. 412; Lacordaire, 1869, Genera Coleopt., 8: 489; LeConte and Horn, 1883, Smithson. Misc. Coll., XXVI, 507: 291; Leng, 1886, Entom. Amer., 2: 27, 29; Casey, 1912, Mem. Coleopt., 3: 310; Reitter, 1912, Faun. Germ., Käfer, 4: 28; Planet, 1924, Encycl. Ent., A, 2: 133; Portevin, 1927, Encycl. Ent., 2 (suppl.): 22; Scheerpeltz, 1930, Tierw. Mitteleur., Käfer, 5 (2): 209.

Pilema LeConte, 1873, Smithson. Misc. Coll. XI, 264; 191, 265: 306.

Callimellum Strand, 1928, Ent. Nachr. Bl., 2: 2, Plavilstshikov, 1932, Best.-Tab. eur. Coleopt., 102: 81, 100.

Pubescence sparse, flying hairs numerous, depressed hairs few; punctation coarse. Head short, front declivous, vertex canaliculate; clypeus deeply impressed at base; eyes deeply emarginate; antennæ shorter than the body in both sexes; palpi slender, last segment cylindrical. Pronotum about as wide as long, sides obtusely angulate, disk tuberculate; prosternum very narrowly separating coxæ; intercoxal process of mesosternum at least as broad as coxæ, truncate; metepisterna broad, not greatly attenuated apically; elytral punctation coarse, distinct throughout, apices dehiscent, inner angle acute; legs slender, femora moderately clavate; posterior tibiæ curved, first segment of posterior tarsi about as long as following two together.

Genotype: *Necydalis femorata* Germar.

Lampropterus occurs throughout the Palearctic Region but in North America is represented by two species on the Pacific coast.

Genus *Pseudopilema* Linsley, new genus

Pubescence sparse, consisting mostly of flying hairs; punctation coarse. Head short; front declivous, vertex canaliculate; last segment slightly oval.

Pronotum about as wide as long, constricted at base and apex, sides obtusely angulate, disk tuberculate; anterior coxæ distinctly separated by prosternum; intercoxal process of mesosternum less than twice as wide as that of prosternum, much narrower than width of coxæ; metepisterna attenuated apically; elytra coarsely punctured at base, the punctures becoming obsolete beyond middle, apices separately rounded; legs slender, femora moderately clavate, posterior tibiæ straight.

Genotype: *Callimus hoppingi* Van Dyke.

This new genus is proposed for a species which differs from *Lampropterus* in having the anterior and intermediate coxal cavities narrowly separated, the metepisterna attenuated posteriorly, the elytral punctures becoming obsolete over the apical one-third, and the posterior tibiæ straight.

Genus *Megobrium* LeConte

Megobrium LeConte, 1873, *Smithson. Misc. Coll.*, XI, 264: 192, 265: 306; LeConte and Horn, 1883, *Smithson. Misc. Coll.*, XXVI, 507: 291; Leng, 1886, *Entom. Amer.*, 2: 27.

Pubescence sparse, flying hairs numerous, depressed hairs few; punctation coarse. Head with front short, subvertical; vertex distinctly concave between antennal bases; eyes large, moderately emarginate; antennæ longer than the body in the male; palpi short, last segment slightly oval, truncate at apex. Pronotum longer than wide, broadly, equally constricted at base and apex, lateral tubercles large, dorsal tubercles small but distinct; prosternum narrowly separating coxæ; intercoxal process of mesosternum several times as wide as that of prosternum; metepisterna attenuated apically; elytral punctation becoming obsolete beyond middle, apices separately rounded, legs slender; femora not strongly clavate, posterior tibiæ straight, first segment of posterior tarsi a little longer than following two together.

Genotype: *Megobrium edwardsi* LeConte (by single reference).

In this genus there are two post-cubital veins in the wing as in the true O브리ini. The remaining characters, however, are those of the Hyboderini. A single species is known, confined to California.

Tribe *Molorchini* Thomson

C. G. Thomson, 1866, *Skand. Coleopt.*, 8: 43, *Molorchina*.

Lacordaire, 1869, *Genera Coleopt.*, 8: 482, *Molorchides*.

Gahan, 1906, Fauna Brit. India, Coleopt., **1**: 169.

Plavilstshikov, 1932, Best.-Tab. eur. Coleopt., **102**: 79, *Molorchina*.

Matushita, 1933, Jour. Fac. Agr., Hokkaido Univ., **34**: 221.

Gressitt, 1939, Ling. Sci. Jour., **18**: 10.

Head short; eyes finely granulated; antennæ with second segment small, much less than one-half as long as third segment; palpi short, subequal, last segment not dilated; ligula membranous. Pronotum with sides rounded, scarcely tuberculate; anterior coxæ globose, cavities angulate externally, open posteriorly; intermediate coxal cavities open to epimera, intercoxal process narrow, triangular, truncate behind; mesonotum without a well-defined stridulatory area; elytra short, less than one-half as long as abdomen, apices rounded or truncate; wings without post-cubital veins; legs moderately long, femora clavate. Abdomen with sternites unequal, gradually diminishing in length, not abnormally modified in female.

The tribe Molorchini differs from the Stenopterini, with which it has been combined by recent workers, by having abbreviated (not subulate) elytra which cover less than half of the abdomen, posteriorly open anterior coxal cavities, no mesonotal stridulatory area, a narrow intercoxal process on the mesosternum, and no post-cubital veins in the wing.

Genus *Molorehus* Fabricius

Molorchus Fabricius, 1792, Ent. Syst., **1**: 356; Mulsant, 1839, Coleopt. France, Longic., p. 107; J. Thomson, 1864, Systema Ceramb., p. 411; C. G. Thomson, 1866, Skand. Coleopt., **8**: 43; Lacordaire, 1869, Genera Coleopt., **8**: 486; LeConte, 1873, Smithson. Misc. Coll., XI, **265**: 307; LeConte and Horn, 1883, Smithson. Misc. Coll., XXVI, **507**: 292; Leng, 1886, Entom. Amer., **2**: 27, 30; Gahan, 1906, Fauna Brit. India, Coleopt., **1**: 169; Blatchley, 1910, Coleopt. Indiana, p. 1028; Plavilstshikov, 1932, Best.-Tab. eur. Coleopt., **102**: 81, 93.

Heliomanes Newman, 1840, Entom., **1**: 17; LeConte, 1850, Jour. Acad. Nat. Sci. Phila., (2) **2**: 21.

Glaphyra Newman, 1840, Entom., **1**: 19; LeConte, 1850, Jour. Acad. Nat. Sci. Phila., (2) **2**: 38.

Laphyra Newman, 1842, Entom., **1**: 418.

Head with front short, vertical; vertex slightly concave between antennal bases, antennæ much longer than body in male, shorter than body in female, eleventh segment appendiculate or divided in male, simple in female; eyes deeply emarginate. Pronotum at least as long as broad, constricted at base, feebly so at apex, disk roughened or calloused; prosternum with intercoxal process very narrow; elytral apices dehiscent; legs elongate, posterior pair attaining apex of abdomen in male; tarsi slender, first segment of posterior pair as long as following two together.

Genotype: *Necydalis minor* Linnaeus (Thomson designation, 1864).

Molorchus is dominant in the Holarctic region but is also represented in the Indomalaysian and Australian faunas. Four species occur in North America, one ranging from coast to coast, two confined to the Pacific slope, and one described from the West Indies.

Tribe Stenopterini LeConte

LeConte, 1863, *Smithson. Misc. Coll.*, XI, 265: 306, *Stenopterini*.

LeConte and Horn, 1883, *Smithson. Misc. Coll.*, XXVI, 507: 292, *Stenopterini*.

Blatchley, 1910, *Coleopt. Indiana*, p. 1028, *Stenopterini*.

Reitter, 1912, *Faun. Germ., Käfer*, 4: 28, *Stenopterina*.

Scheerpeltz, 1930, *Tierw. Mitteleur., Käfer*, 5 (2): 209.

Head porrect; front large, oblique; antennæ with second segment small, less than one-half as long as third segment; palpi short, subequal, last segment not dilated; ligula membranous. Pronotum tuberculate at sides; anterior coxæ globose, cavities angulate externally, closed posteriorly; intermediate coxal cavities open to epimera, intercoxal process broad, flat, emarginate posteriorly; mesonotum with a large stridulatory area; elytra elongate, subulate, covering more than half of the abdomen; wings with a single post-cubital vein; legs long, femora clavate. Abdomen with sternites unequal, gradually diminishing in length, not abnormally modified in female.

A single genus, *Callimoxys*, represents this tribe in North America.

Genus *Callimoxys* Kraatz

Callimoxys Kraatz, 1863, Berl. Ent. Zeitschr., 7: 105; Thomson, 1864, Systema Ceramb., p. 412; Fairmaire, 1864, Gen. Coleopt. d'Eur., 4: 152; Lacordaire, 1869, Gen. Coleopt., 8: 489; LeConte, 1873, Smithson. Misc. Coll., XI, 265: 307; LeConte and Horn, 1883, Smithson. Misc. Coll., XXVI, 507: 292; Leng, 1885, Entom. Amer., 2: 27; Reitter, 1912, Faun. Germ. Käfer, 4: 28; Plavilstshikov, 1932, Best.-Tab. eur. Coleopt., 102; 82, 106.

Head elongate; front short, declivous; vertex deeply impressed between antennal bases; antennæ shorter than the body in both sexes, eleven segmented; eyes deeply emarginate. Pronotum longer than broad, narrower in front, widest behind middle, sides tumid, disk tuberculate; anterior coxæ separated by prosternum; intercoxal process of mesosternum broad; elytra with apices attenuated, subulate; legs elongate, posterior pair attaining apex of abdomen in male, femora suddenly clavate, posterior tibiæ curved inwards, outer face armed with two rows of acute tubercles.

Genotype: *Stenopterus gracilis* Brullé (by single reference).

Three species comprise this genus, one in southern Europe, two in North America.

STUDIES ON THE BIOLOGY OF THE EPHEMER- OPTERA. II. THE NUPTIAL FLIGHT¹

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The spectacular nuptial flight of the ephemerids early attracted the attention of scientists. Swammerdam (1675) recorded the emergence, nuptial flight, and oviposition of *Palinogenia longicauda* on the rivers of Holland. He misunderstood the character of the nuptial flight and thought fertilization took place after the eggs had been deposited in the water. Reaumur (1742) observed the nuptial flight of *Ephoron virgo* at Paris. Both Swammerdam and Reaumur studied species whose flights take place at dusk or after darkness has fallen, and thus they had great difficulty in seeing the actual behavior of the insects. When Collinson (1746) observed the flight of *Ephemera vulgata* at Winchester, England, he noted that copulation took place in the air and saw the typical up-and-down movements of the individuals. In 1750, he reported the observations of John Bartram on an ephemerid species from the Schuylkill River, Philadelphia. Bartram had seen a typical flight and also concluded that copulation was achieved in the air. Charles de Geer (1755 and 1771) observed *Ephemera vulgata* in Sweden, and saw that the male copulated with the female by placing himself beneath her and then bending his abdomen upwards. Because of the short time that the copulatory act lasted, he was not able to ascertain where the male grasped the female with his fore legs. Eaton (1883) has given a brief account of the behavior of the ephemerids during the nuptial flight, and since then many workers have noted certain characteristic and interesting aspects of the flights of these insects. Morgan (1913), Needham (1927), and Needham, Traver, Hsu, etc. (1935) have dealt with the subject at some length. There are, however, phases of the problem that have not been elucidated; to present these data properly, it is necessary to review the problem in its entirety.

¹ I wish to thank the authorities of the American Museum of Natural History and especially Dr. Frank E. Lutz for making available space in which to conduct research work.

THE NUPTIAL DANCE

On the basis of present information, all species of ephemerids, except for possibly a few parthenogenic ones, engage in a nuptial flight during their brief life as winged individuals. This flight results in copulation and the insemination of the female. Although there are variations and modifications to the flight, as will be noted later, it typically follows a rather standard pattern. Such a standard flight pattern can be observed in genera as diverse and distantly related as *Baetisca*, *Hexagenia*, *Siphonurus*, *Ephemerella*, and *Baëtis*.

Briefly, the general pattern of this phenomenon, in which the males play the dominant role, is as follows: After preliminary patrolling, a number of males gather near or over a body of water, into which the females will ultimately oviposit, and commence an attractive and characteristic up-and-down dance. Sometimes the aggregation consists of countless individuals; at other times it is made up of only a few males. Now and then a solitary male can be seen in flight. The upward motion of the dance is accomplished by the individual flying upward and forward with strong, steady wing strokes. Meanwhile the fore legs are stretched forward, the straightened body is elevated anteriorly and slopes downward posteriorly; the caudal cerci are parallel with each other and extend posteriorly along the longitudinal axis of the body. Having propelled himself upward and forward for a brief time, he then ceases flying and, due to the force of gravity, floats earthward with the wings extended upward and somewhat outward. At the same time much of the body, especially the thorax, comes to be almost parallel with the earth while the posterior end of the abdomen is bent slightly upwards. The long cerci extend divergently backwards and upwards. These cerci are always divergent and never parallel during the downward movement. The fore legs are kept extended forward and are bent slightly upwards. Except possibly for the diverging of the cerci, the position assumed in the downward flight is entirely passive and due to air resistance and gravity rather than to any activity on the part of the individual. The long cerci and fore legs seem to serve as balancers and stabilizers in this passive downward movement. It is to be noted that the

fluted, fan-like character of the wings is helpful in maintaining the individual on an even keel. As Needham, Traver, Hsu, etc. (1935, p. 103) have pointed out, the specimens often sway from side to side as they passively descend. This is due to the effect of the wind currents upon the inactive, lightly balanced individuals as they float earthward.

In such a nuptial dance there is no sign of timing among the insects. Thus some are ascending while others are descending, and so a constant passing and re-passing takes place.

The insects always face into the wind if there is any air movement. If the air currents are strong and gusty, then the individuals are often blown away or down into the surrounding vegetation. In a moderate or gentle breeze, however, the forward component of the upward flight just about equals the backward component of the downward drop and the individual rises and falls repeatedly in about the same area. If there is a slight breeze or if air movements are completely lacking, then the downward drop is vertical or almost so and the individual moves forward with each upward flight. After a number of upward and forward flights and downward drops, the insect makes a quick reversal and faces in the opposite direction. There then occurs a repetition of the ups and downs. Thus, invariably the nuptial swarm is maintained over a relatively small area and all the individuals fly in parallel directions.

Ephemerids can reverse their direction of flight with almost lightning-like rapidity, can fly upward, downward, forward, and, as is recorded below, they can hover; but they are apparently incapable of lateral flight movements.

After the dance of the males has continued for a time, individual females come flying into the swarm. Unlike the males, they fly on an even keel, parallel to the ground, but usually in the same direction as the males. The combined methods of flight of the two sexes result in the female flying above a male that is dancing up and down. The male recognizes the female and on his up-flight approaches her from below, seizes her and the pair immediately joins in copulation. De Geer (1755) was the first to report that the male seizes the female from below, but he did not see how it is accomplished. The feat is accomplished

because of the male's ability to supinate his entire fore tarsi and bend them backwards and thus grasp the pronotum of the female with his tarsal claws. Considerable speculation has arisen as to the exact spot on the female that the male grasps. Needham (1927) and Needham, Traver, Hsu, etc. (1935, fig. 13) indicate that the mesonotum at the wing roots is the chosen spot. All other workers have indicated the pronotum. My own observations suggest that the posteromedial edge of the pronotum is the point of attachment.

Almost simultaneously the male bends the end of his abdomen upward and forward and grasps the eighth abdominal segment of the female with his genital forceps. At the same time the penes are inserted into the genital ducts of the female which open on the conjunctival membrane between the seventh and eighth sternites. In such a position the head of the male lies under the mesothorax of the female. Thus the thorax of the male extends posterior to that of the female and the male's abdomen is bent acutely upward and forward.

The united pair continues to fly but, with few exceptions, its combined flight powers are not sufficient to support them for long and they gradually descend toward the ground. Generally the two separate before they reach the substratum over which they have been flying. Thus the copulatory act is restricted to a few seconds. In *Siphloplecton basale*, however, not only does the united pair continue its combined flight but it is able to avoid other males that attempt to displace the copulating male. Repeated timings on this species have shown that even here copulation lasts only from one to one and one-half minutes.

Sometimes pairs will remain in copula even after they have descended to the substratum. De Geer (1771) observed pairs of *Ephemera vulgata* upon the vegetation. Needham, Traver, Hsu, etc. (1935) relate that many pairs of *Siphonurus* sp.? were observed to light on a parked car. Eaton (1883) observed a pair of the genus *Ecdyonurus* remaining in copula for at least "six or seven minutes after they had come to rest." Pairs of *Siphloplecton basale* will remain in copula when captured in an insect net. Needham (1927) found a pair of *Cinygmula mimus* in copula even after the insects had been killed in a cyanide jar.

A figure of this pair has been published but is not typical in that the male is too far forward with respect to the female, his abdomen is not sufficiently bent, and the fore tarsal claws reach to the middle of the mesothorax instead of to the posterior edge of the prothorax. A much more accurate picture of copulation is given in "The Biology of Mayflies" (1935, fig. 13) except that the fore legs of the male are not delineated correctly.

VARIATIONS OF THE NUPTIAL FLIGHT

There are variations to the typical flight described above that should be noted. Eaton (1883, p. 9) writes that *Heptagenia* and its allies maintain a hovering position so that they are "locally designated in the valley of the Axe (Devon) as Yellow Uprights." Cook (1940) observed such a behavior in *Stenonema vicarium*. I have seen it repeatedly in various members of the genus *Stenonema*. In such cases the flight varies from the typical in that the male, instead of moving up and down, *hovers on an even level*, a dance accomplished by the insect assuming the following position: the body is held rigid and straight with the longitudinal axis almost perpendicular to the ground. The fore legs are extended along the axis of the body. The caudal cerci are held widely divergent and almost parallel to the ground, *i.e.*, almost at right angles to the longitudinal axis of the body, while the wings are rotated forward. An individual when flying in this manner is reminiscent of a feeding humming bird. In such a position the male can hover in one place or move forward and parallel to the substratum at a slow rate. It can not fly sideways or reverse its flight. In order to achieve a reversal of direction, the individual tips forward abruptly and flies in normal manner for a short distance, *i.e.*, a foot or so, reverses and then reassumes the hovering flight. What factor or factors are responsible for the individual assuming the hovering type of flight are obscure. Apparently only some members of the family Heptageniidae are capable of this variation. It is to be noted that such a flight pattern is assumed only when there is no wind.

DOWNWARD FLIGHT MOVEMENTS

Not always is the downward drop of the male in the nuptial dance passive. Sometimes he actually flies downward. Need-

ham, Traver, Hsu, etc. (1935, p. 103) report that *Baëtis flavistrigia* makes the upward part of the flight with great rapidity while the downward passive drop gives the impression of a dogbane seed floating earthward. If, however, the nuptial flight of this species is conducted in a brisk breeze, then the downward drop is accomplished by vigorous movements of the wings and it is just as rapid as the upward movement, and the individual keeps rising and falling in an almost vertical line. So far as my observations go, such downward wing-movements are restricted to small, light, fragile species. It has not been observed in large, heavy-bodied species.

SUBSTRATUM COPULATION

Practically all species of ephemerids mate in the air, although Eaton (1883, p. 10) reports that *Plethogenesia papuana* mates on the surface of the water. In this species the fore legs of the males, because of the abbreviated tarsi, are short. A similar condition is found in the species of the genera *Mortogenesia* and *Anagenesia*. It is possible that the species of all three of these specialized genera may mate on the surface of the water.

Occasionally species that normally mate in the air will attempt to copulate while on a firm substratum. Reaumur (1742) observed that the male individuals of *Ephoron album*, when attracted to land near his lantern, would attempt to copulate with females with whom they came in contact.

While watching a pair of *Ephemera guttulata* on the underside of a *Platanus occidentalis* leaf, I observed that the male brought himself parallel and close beside the female, grasped her abdomen with his genital forceps and proceeded to copulate in the usual manner. In this instance, the fore legs of the male were not used and both individuals remained attached to the leaf.

SEMI-NOCTURNAL AND NOCTURNAL SPECIES

Species of genera such as *Ephoron*, *Campsurus*, and *Palinogenia* emerge just at darkness or even during the night. Since the meso- and metathoracic legs of the females and the males of *Campsurus* are either absent (*Campsurus*), or so weak (*Ephoron* and *Palinogenia*) that they can not support the individuals,

they mate immediately; the females oviposit, and then the individuals of both sexes die. The total life span of the winged stages in such species is from one to four hours. The nymphs of these are negatively phototactic and positively thigmotactic burrowing forms that normally never come in contact with the light. Thus a complete generation may exist without the individuals seeing daylight. Such species do not indulge in a typical nuptial dance. The males fly rapidly back and forth over the body of water from which they have emerged. The flight is parallel or almost so with the water and without the up-and-down motion. Tientsuu (1935) reports that *Ephoron ladogensis* males have an undulating flight. Every so often the individuals quickly reverse their direction of flight. This, plus the rapid beating of the wings, gives these forms the appearance of being in a great hurry. Just how the males find the females in the total or almost total darkness, I have never been able to observe exactly. All these males have undivided compound eyes that are relatively small. Perhaps their vision is extremely acute, but fragmentary observations indicate that they may establish contact by tactile rather than visual means. In this connection it should be noted that these species usually emerge in great numbers. This plus the fact that the nuptial flight is held close to the surface of the water insure a relatively large chance for actual contact between individuals. The method of copulation seems to be the same as in all other species.

In these species, the female remains during her entire winged existence a subimago.

COMPOUND EYES OF DIURNAL SPECIES

Except for the semi-nocturnal or nocturnal species, the ephemerid males have large eyes that are greatly expanded on the dorsal surface. In many the eyes are actually divided into a large dorsal and a smaller ventro-lateral portion. This condition reaches its extreme development in *Baëtis* and its relatives where the dorsal part is carried upward on a stalk and the visual elements face dorsally while the small ventral portion is more rounded and the visual elements face outward somewhat as in the normal insect eye. Even in those species in which the eye is not completely divided morphologically (such as *Hexagenia*,

Stenonema, *Siphonurus*, etc.), it is easily seen that there is a functional division.

Repeated observations indicate that the dorsal part of the eye is used by the male to recognize the female as she flies over him while he is engaged in the nuptial dance. In the morphologically divided eye types where the dorsal part faces upward (*i.e.*, *Baëtis*, *Pseudocloëon*, etc.), the upward component of the nuptial dance is almost vertical. Conversely those species which do not have the eyes separated morphologically and in which the upper part is only slightly larger than the lower part (*i.e.*, *Siphonurus*, *Hexagenia*, *Stenonema*, etc.), the upward movement of the nuptial dance is not vertical but forms about a forty-five degree angle with the substratum.

The focal distance of the upper part of the eye apparently is rather short. The male seizes only those females that come within a short distance of him. The males normally are able to identify the females of their own species, but often they make mistakes, if other insects are flying in the same immediate area. I have seen *Stenonema fuscum* males repeatedly attempt to copulate with caddis and stone flies. A *Cinygmula mimus* male was captured while trying to mate with a large chironomid. This may explain Venour's observation (1906), upon *E. dancia* males mating with female subimagos that had just emerged and were forced to fly through the nuptial dance in order to reach the surrounding vegetation. Ide (1930), has also observed male imagos of *Callibaëtis americanus* mate with female subimagos of the same species.

The lateroventral part of the eye is employed by all species to prevent the individual from coming into close proximity with large objects or protuberances of the substratum. The ephemerids, especially the males during the nuptial flight, are extremely alert and have a rather keen vision. Anyone who has collected ephemerids can testify that while flying they avoid with great consistency any object that projects from the background. Thus if a bridge crosses a stream over which they are engaged in nuptial flight, they will invariably avoid it, rising when they approach it so that they maintain the same distance from it that they do from the surface of the water. When a collector places

himself upon the bridge, they fly still higher over the spot where he is standing. This holds true whether he moves or remains perfectly still.

TIME OF FLIGHT

As indicated above, most species are diurnal. These species mate during the day or at twilight, the exact time depending upon environmental and seasonal differences as well as upon specific peculiarities.

In general those small species having hyaline wings and males in which the abdominal segments 2-7 are hyaline or semi-hyaline mate during the middle of the day and only rarely at twilight. Thus species of *Baëtis*, *Callibaëtis*, *Pseudocloëon*, *Cloëon*, *Centroptilium*, *Paraleptophlebia*, *Habrophlebia* and *Habrophleboidea* are often seen swarming at various times in broad daylight. I have a record of *B. moffati* mating at seven o'clock in the morning.

Large, dark, heavy-bodied, conspicuous species such as *Hexagenia*, *Ephemera*, *Potamanthus*, *Isonychia* and most members of the family *Heptageniidae* usually swarm from just at sundown to darkness.

No hard and fast rules can be drawn for any species because environmental effects play a large part in the timing of the nuptial dance as can be seen by the following typical observation.

While collecting on Spring Creek in Yellowstone Park, Wyoming, July 7, 1936, a thunder shower of small dimensions developed about five o'clock in the afternoon. The spot where I was collecting was on the edge of the storm area and only a few raindrops fell at this point. Individuals of both sexes of *Ephemera simulans* appeared and engaged in a nuptial flight. In a few minutes the storm disappeared and the individuals immediately dispersed and were not to be seen until they reappeared just at sundown about two hours later. Repeatedly I have observed, in many diverse genera, that the appearance of a storm with its attendant drop in temperature and light intensity will stimulate adult ephemerids to activity. Perhaps the relative humidity is also important since the ephemerids are rather sensitive to desiccation.

A combination of factors—latitude, elevation, season, temperature, humidity, light intensity, and atmospheric pressure—rather than any single one is probably responsible for stimulating the imagoes to leave their resting place on the surrounding vegetation and indulge in the nuptial dance. Thus the species that normally mate at twilight will sometimes be found mating in the middle of the day.

PLACE OF NUPTIAL FLIGHT

Although no perfect rule can be drawn, members of each genus are fairly consistent in the locality selected for the nuptial dance. Ephoron and Campsurus mate over the water; Ephemera over the water or close by; Hexagenia along the edge of the shore; Siphonoplecton, Cænis, Choroterpes, Stenonema, Iron, Heptagenia, Cinygmula, and Rhithrogena usually but not always engage in their nuptials over the surface of the water. I have, however, observed exceptions in all of these genera.

In comparison, I have never seen Blasturus, Tricorythus or Ephemerella, with the sole exception of the early spring *E. subvaria*, swarming over the water. These three genera all choose open areas a distance from the stream for their dance.

Small, clear-winged species of Thraululus, Habrophlebia, Habrophleboidea, Baëtis, Cloëon, Pseudocloëon, and many species of Paraleptophlebia choose small openings in the trees or bushes along the edge of a body of water. Only seldom are they seen over the water.

Species of Isonychia and Siphonurus choose almost any spot: sometimes over the water, sometimes over a grassy meadow, sometimes in the tree-tops. Individuals of a single species may be found in different localities on the same day at the same time.

Ephemerids, both males and females, often mistake wet roads for bodies of water, and forms which normally mate over water will often be found dancing and ovipositing over a road.

The height at which the dance takes place is also extremely variable. Generally when a strong wind is blowing, the individuals are close to the ground. Under normal conditions most species dance from five to thirty feet above the substratum. A

few, such as *Ephemerella*, usually conduct their dance high in the air, about thirty to one hundred feet above the ground.

FATE OF THE MATED INDIVIDUALS

Copulation achieved, the female flies off to deposit her eggs. The male, being polygamous, returns to the dance. This dance may continue for several hours. For species that mate at twilight, darkness is the limiting factor to the dance of the males. In species of *Campsurus* and *Ephoron* the nuptial dance lasts until the individuals are exhausted. Apparently the same thing happens to numerous individuals of other species.

The males of most species, if they have not mated or are not exhausted, return at the end of the dance to the vegetation and await the dance of the following day. Careful watching of a dance will always show that a large percentage of the males fly back into the surrounding vegetation. Since they are unable to feed in the winged state, they must live upon stored energy. A still greater danger is that of desiccation. I have often seen males fly rapidly from the vegetation and drop down upon the surface of the water with wings outspread. After remaining in this position for a few seconds, they would then fly back into the vegetation. As is well known the adult ephemerid's body surface is hydrofugic. Experiment has shown, however, that the area of the degenerate mouthparts is not hydrofugic in the imagoes and that individuals are capable of imbibing water. Apparently the males referred to above return to the water for a drink.

In any case, the winged life span of an ephemerid is relatively short and has only one function: the fertilization and oviposition of the ova.

CONCLUSIONS

1. All ephemerids, with the exception of a few parthenogenic forms, as adults engage in a nuptial dance which insures the males copulating with the females.

2. This dance and the copulatory movements follow a rather standard pattern for all species of the order. This is another evidence that the order is monophyletic.

3. There are a few modifications to the standard dance pattern. These (hovering, horizontal and vertical) are modifications to meet specialized conditions.

4. The dance may take place at any time of day or night depending upon the species and environmental conditions. Within limits, however, each species has a preferred time for mating.

5. Various genera usually choose specific types of localities to engage in the dance.

6. The males of many species live several days and engage in several nuptial dances. They apparently counteract desiccation by their ability to imbibe water.

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A NOTE ON REARING THE BROOD OF POLISTES FUSCATUS, FABRICIUS (HYMENOPTERA— VESPIDÆ)

On several occasions during the past season, it has been my fortune to collect several nests of *Polistes fuscatus*, Fabricius. As it was expedient to kill off all the adults in collecting the nests, the brood had no means of securing nourishment. It was decided to attempt to rear the existing brood, which ranged from eggs to nearly matured pupæ.

The larvæ required both a liquid and solid diet. The liquids were administered to each larva through a small glass pipette. A drop of juice or water slightly smaller than the head of the larva was discovered to be sufficient for one drink; naturally this volume would vary with the size of the larva. All larvæ greedily accepted tap water and would occasionally accept a dilute aqueous solution of glucose or saccharose. Upon occasion the smaller larvæ would accept the offerings of pasteurized milk but this was not consumed with any avidity.

The solid diet was prepared by chopping small bits of meat into fragments about one half of one cubic millimeter in volume and then making a paste out of the mass by the addition of water. This kept the meats juicy and permitted the larvæ to handle the particles more easily. Forceps with medium size jaws were used in administering the solid foods; as much food as would adhere to the forceps through capillarity was sufficient to feed one large larva. Raw and cooked beef, lamb and chicken, prepared as above, were readily eaten as were liverwurst and ham (spiced).

Two or three feedings and as many drinks every day were enough to satiate the greedy larvæ and permitted them to grow at a reasonable rate.

The absence of trophallactic relations with adults seemed not to have an effect on the development of the brood, although at all times the larger larvæ would produce their trophallactic secretions when touched upon the head. These larvæ would indulge in autotrophallaxis by imbibing their own secretions, independently of how well they were fed. This imbibition seems

necessary for the maintenance of nest cleanliness as the paper would soon become sodden and moldy if the secretion were not removed; it therefore seems that autotrophallaxis might be a practical habit rather than an indication of weakness in the colony.

To gain access into the deep cells in the middle of the nests, it was found expedient to tear away the paper walls of the cells. When the larvæ in these cells began to pupate they could not produce enough silk to build up their compartments. Indeed, they had no instinct for repairing the nest. One larva even tried to build a cocoon cap attached only to the head of an adjacent larva.

To circumvent this difficulty, two types of artificial cell were made. One was a block of wood bored with holes 5 mm. in diameter and 16 mm. in depth; the other was a set of 5 mm. diameter paper tubes. When the large larvæ were observed to move their heads about in the circular motion characteristic of the pre-pupating *Polistes*, or when they would accept no further food, they were removed from the original nest and placed in either the wooden block or the paper tubes. These served as a satisfactory substitute for the nest as the larvæ spun their white silk pupal caps over the apertures and settled down to pupation. Perfectly normal adults emerged in due time.

Adults that emerged prior to the pupation of the last larva were removed that they might not interfere with the experiments.

The span of life of the larvæ could be varied at will by increasing or decreasing the feeding. Fifteen days to six weeks were spent in the larval stage by individuals that were respectively overfed and nearly starved. The average pupation period was nineteen days with the temperature varying from 66 to 87 degrees F.

The only real difficulty encountered in rearing the brood was in feeding the smaller larvæ whose capacity was so small that even the smallest portions offered them could not be completely consumed. This created a problem in nest cleanliness, so the excess had to be carefully removed after each feeding.

Another important consideration in the health of the brood was sufficient ventilation. In closed or poorly ventilated con-

tainers, the formation of molds caused a high mortality among both larvæ and pupæ. Nests fully exposed on a shelf or table remained free from molds although precautions were necessarily taken against the predatory activities of ants.

The inverted position of the nest seemed not to interfere with the more or less normal development of the young.

By virtue of the few precautions mentioned, it was found practicable to rear adult *Polistes* from eggs, thus entirely supplanting the natural relations between adult and brood. Although the trick of rearing *Polistes* is of no great consequence, the possibility of supplanting the adults may lead to further investigations on their social conduct.—ALBRO TILTON GAUL.

BOOK NOTICE

Introducing Insects, A Book for Beginners. By James Needham, with illustrations by Ellen Edmonson. The Jaques Cattell Press, Lancaster, Pennsylvania, 1940. $7\frac{1}{2} \times 5\frac{1}{2}$ inches. vi + 129 pp., illus. \$1.50 postpaid.

This is a slim, attractively bound, well printed volume by a well-known entomologist whose writings always command respect, and attention. In it, Dr. Needham refrains from "humanizing" his subjects and also from treating them in journalistic style, which methods are commonly used by writers in attempting to popularize insects. Instead he introduces the insects as they really are, in simple language free of technicalities, and his examples are all species that one meets within everyday life in the home, in our possessions, in our food, and in our rambles in fields and along roadsides.

In addition to sections on butterflies, dragonflies, common caterpillars, leaf-eating beetles, mosquitoes, insects that eat our food, etc., there are sections devoted to collecting and rearing insects, and to the importance and pleasure of studying them.

It is a good book for the young or old beginner in entomology and for the citizen of any age who is inquisitive enough to want to know something reliable about the creatures with which he comes in contact at various times during his lifetime, and the numerous illustrations in the text add to its merit.—H. B. W.

An Introduction to Entomology. By John Henry Comstock, Late Professor of Entomology and Invertebrate Zoology in Cornell University. Ninth edition, revised. Ithaca, New York, Comstock Publishing Company, Inc., 1940. $9\frac{1}{2} \times 6$ inches. xix + 1064 pp., Frontis., 1228 Figs. \$5.00.

The appearance of the ninth edition of this work of acknowledged excellence makes superfluous any praise that I might bestow upon it. And so this notice is merely an announcement of its availability in a revised form and of its recognition of the interest in biological control by its revision and extended discussion of certain superfamilies of the Hymenoptera. Although entitled *An Introduction to Entomology*, it is really a comprehensive general treatise involving various ramifications of the external and internal anatomy of insects, of metamorphosis, and of classification, with numerous analytical tables for the determination of families. In this latest edition, new discoveries and opinions have been included.

Its publication reminds me that the only book I ever borrowed and failed to return was a copy of *A Manual for the Study of Insects*, by John Henry Comstock and Anna Botsford Comstock, 2nd edition, published in 1897. I borrowed it in 1900 and still have it. I always meant to return it and never felt right about keeping it so long, but at the time it was indispensable to me, and I could not spare it. When I was ready to return it, the original owner was no longer alive.

The present work, I am sure, is just as necessary to present day entomologists, but I recommend its purchase rather than borrowing and keeping it for forty years.—H. B. W.

BOOK REVIEW

Fauna of British India, Diptera VI, Calliphoridae. By R. Senior-White, D. Aubertin and J. Smart (London, March 28, 1940).

This beautiful volume of 288 pages, 152 figures and 1 map is an important contribution to the subject of the Oriental Muscoidea, but unfortunately it is marred by numerous errors. It appears from the preface that Senior-White is mainly responsible for the system of classification adopted including generic scope, as well as for terms and names employed in the volume. It is much to be deplored that uniformity in taxonomy and terminology is still a postponed consummation. Still more to be deplored is the current refusal to accept the priority principle in nomenclature.

As to taxonomy: *Bengalia* and *Pollenia* and their allies are not nearly so closely related to *Calliphora* as is *Chrysomya*, yet they are included in the *Calliphorinae* while *Chrysomya* is recognized as the type of a separate subfamily. The *Chrysomya* contingent merits no more than tribal rank. Both bare and ciliate remigia occur in the small tribe *Mesembrinellini*, which shows that this character is not even of tribal value.

Tainanina is included in the *Calliphorinae*, but it belongs unmistakably in the very distinct family *Melanophoridae*.

Chætoptiliopsis is also included in the *Calliphorinae*. According to its author, it does not belong even in this superfamily but is referable to the *Macquartiini* in the superfamily *Oestroidea*. Baranov's reference implies a well developed infrascutellum in *Chætoptiliopsis*. Both the original description and the one given here indicate the correctness of his reference.

Elephantolæmus is abundantly distinct from *Booponus* generically by having markedly different head and both belong with *Bengalia* tribally. Both the *Bengalia* and the *Pollenia* groups belong in the family *Rhiniidæ*.

Numerous valid genera are sunk as synonyms in the volume, but they will eventually be recognized on their genetic index (see MM, IV, 269).

As to terminology: The great desirability of a uniform English terminology securely based on morphology led the reviewer to make the most careful selection of terms possible for the anatomic parts of the fly and the early stages both externally and internally. It is given in MM, I & II. The earliest and most appropriate terms are there fully elucidated to prevent confusion and error. A quite different terminology is employed in the present volume with the apology that, while it has practically no morphological value, it was chosen for convenience and on the grounds of usage. It must not be forgotten that a sound and lasting terminology can be based only on a valid interpretation of homology, which in turn can be based only on morphology. Few exceptions to this rule are permissible and even these are questionable (MM, II, 63).

Evidently the student of myiology must still for a time learn the separate terminologies of all the workers publishing not only in his own language but in all other languages employed. This is a great hardship, causing great loss of time and frequently much confusion if not actual error. Further, why use a whole descriptive clause often repeated, as in the subfamily key on page 26 and elsewhere, to avoid saying "greater ampulla"? Obviously because the user did not know that the part has a distinctive name. In same key, a four-line sentence could have been far more intelligibly expressed by saying "posthumeral bristle" or just "PH" present or absent. Besides, the sentence says what it does not mean. It means the *posterior* (not anterior) two bristles!

As to nomenclature: The earliest generic name used in the volume is Sarcophaga (1826), yet the Sarcophaginæ are included in the family Calliphoridae, derived from Calliphora (1830), ignoring priority in derivation of group names above the genus. Sarcophaginæ should be Stephanostomatinae, derived from Stephanostoma (1794-1802), which much antedates Sarcophaga. There is at present a mistaken movement afoot to ignore the priority principle in derivation of group names above the genus, but it can not prevail in the long run. Future nomenclature can find stability only in observing this principle. Arbitrary enactment to the contrary can only cause confusion and loss of time.

Further, the original spelling of names must be adhered to in order to avoid confusion and emendations must be treated as synonyms.

Errors in the volume require correction as below, by pagination. Note that Gt means genotype; Ht, holotype; At, allotype; Coll, collection; MM, Manual of Myiology; AMNH, Annals & Magazine of Natural History.

Pp. 28-29. In 1931 Townsend (AMNH, 10, VIII, 375) gave *Cynomya fortis* Wlk. as Gt of Hypopygiopsis on ♂ Ht from Borneo described in 1857. Years later Walker described *Pyrellia fumipennis* ♀ from New Guinea, being evidently same species. His *Silbomyia fumipennis* ♀ from Singapore, described in 1857, is doubtfully the same.

Pp. 32-33. Gt of Calliphora is *vomitorea* L. as shown by Desvoidy's description.

Pp. 37-38. *Tricycleopsis paradoxa* VII is Bengaliini, while *Pseudocalliphora semifulva* Mll. is Calliphorini. Ht ♀ of latter is in Amsterdam.

Pp. 41-42. Hemipyrellia stands on its Gt *curriei* TT. from Mount Coffee, Liberia, which is evidently a distinct species from *fernandica* Mq. from Fernando Po. *H. orientalis* TT. (1927) is distinct on color of antennæ and palpi.

Pp. 46 & 53. Agoracrites was validated by Aubertin (1933), *Lucilia porphyryna* Wlk. being referred to it. Mount Ophir, alias Talaman, is in Sumatra.

P. 70. Ht ♀ of *Caiusa indica* Sf. is in Paris and At ♂ is in Milan (MM, V, 72).

P. 72. *C. dubiosa* VII, is distinct, Ht ♀ in DEL.

Pp. 78-81. Larva of Booponus and that of Elephantoloemus are *certainly* (not probably) the cause of the sores, the two differing markedly in parts attacked.

P. 82. Chætoptiliopsis, as already noted, does not belong in the Muscoidea.

P. 88. Ht ♀ of *Musca jejuna* F. is from Bengal and in Copenhagen F. Coll (AMNH, 10, VIII, 371).

P. 91. Ht ♀ of *Bengalia lateralis* Mq. is in Paris (MM, V, 67).

P. 101. Ht ♂ of *Musca varicolor* F. is in Copenhagen F. Coll (MM, V, 70).

P. 102-103 & 106. *Catapicephala splendens* Mq. is a synonym of *Musca micans* F., Ht ♂ in Copenhagen F. Coll from East Indies. *Trongia viridis* TT. from Siam is same (AMNH, 10, VIII, 375).

Pp. 108-110. *Tainanina grisella* Vll. is a distinct species, the squamal hairs brown. Belongs in Melanophoridae, as already noted. Figure 53 is upside down.

Pp. 111-114. Coquillett's designation (1910) of *cognata* M. as Gt of Melinda is invalid because not originally included. Townsend's designation (1916) of *cerulea* RD. is valid and equals *cognata* M. The synonymic name *cerulea* M. is pre-occupied by Wiedmann (1819). The Sumatran species given as Melinda are Neomelinda, to which may also belong *M. leucocera* RD. from Australia.

Pp. 119-132. *P. townsendi* is a synonym of *Ocrisia testacea* TT. Strange disposition to put all the tribe Polleniini except Wilhelmina in one genus.

P. 133. Ht ♀ of *W. nepenthicola* Vll. is in Amsterdam. The genus and species are Vll.

P. 135. Rondani (Arch. Zool. Modena, III, 27, 1863) said "*Marginalis* del Fabricius, che forma il tipo del Genere Chrysomya." This is invalid as a Gt designation, since this name was not originally included. Coquillett (1910) merely repeated this. Townsend (1916) made the first valid designation as *regalis* RD, which equals *marginalis* W. (not F.). Paracompsomyia and Pycnosoma are synonyms (MM, V, 124). Compsomyia Gt is *Musca megacephala* F., *Callitroga* B is synonym of Compsomyia (MM, V, 126). Somomyia R equals Calliphora (MM, V, 141). The other genera are valid.

P. 137. *M. marginalis* W. Ht ♀ is in Copenhagen Westermann Coll (MM, V, 124).

P. 138. *M. megacephala* F. type locality Guinea was error for East Indies.

P. 149. There is no doubt of the complete absence of Rhiniini in the Americas.

P. 151 & 157-158. Strongyloneura is abundantly distinct from Isomyia, as shown by the characters given for latter's Gt *delectans* Wlk. On his two visits in 1928 to the British Museum, the

reviewer was told that Ht of same was lost. Gt of *Thelychæta* BB. is *chalybea* BB. from Borneo. *Tachina viridaurea* W. from the East Indies belongs to *Rhyncomya*, Ht ♀ in Copenhagen (AMNH, 10, VIII, 372); no ♂ in Copenhagen and no types in Vienna. *Musca viridaurea* W. from Java is congeneric with *chalybea* BB. but not conspecific. *Musca munda* W. from Java is also distinct and the description under 105 is of this species, which is apparently referable to *Strongyloneuropsis*.

Pp. 152–154. Description 100 is of *Eucosmina vittigera* Mll. (not of *Strongyloneuropsis malayensis* TT.). Figure 74 of ♂ genitalia is said to have been drawn from the type of *vittigera*, but the only types of that species are females.

P. 163. Referring to footnote, *S. viridana* TT. types agree with the description in the “parafacial hairs partly or wholly blackish.”

P. 168. The seven species with ♀ Ht can all be determined in the female.

P. 172. Description 119 is of *fulvicornis* Big. *Dictya ænea* F. is a distinct species, Ht ♀ in Copenhagen F. Coll (AMNH, 10, VIII, 372). *Synamphoneuropsis viridis* TT. from Nepal frontier (Sukhwani) is distinct.

Pp. 176–177. *Eucosmina*, given on nonexistent ♂ type page 152 as synonym of *S. malayensis* TT., is here given again as synonym of *Alikangiella* on the actual ♀ types. The descriptions under 100 and 123 are exactly the same except a slip on midtibial bristling. It seems that two of the authors disposed of *Eucosmina* without either one knowing what the other had done and both dispositions got published in the volume! The genus is distinct from *Alikangiella* as well as from *Strongyloneura*.

P. 179. *Metalliopsis setosa* TT. with bare prosternum and 5R widely open is made conspecific with *Chlorrhynchomyia clausa* TT. with bristled prosternum and closed 5R, the two being very distinct generically. Ht ♀ of *C. clausa* is not in the Berlin Museum but in the DEI in Berlin-Dahlem.

P. 183. Gt of *Rhyncomya* is *Musca ruficeps* F. *R. callopis* Lw. does not belong. But *Tachina viridaurea* W. belongs.

P. 187. *Alikangia* Gt is *pulchella* Vll. Genus distinct from *Borbororhinia*.

P. 191. *Musca lunata* F. Ht ♂ is in Copenhagen F Coll (MM, V, 108).

P. 192. *Musca discolor* F. Ht ♂ is in Copenhagen F Coll (MM, V, 98).

P. 197. *Idia xanthogaster* W. Ht ♀ is in Copenhagen Westermann Coll (MM, V, 101).

P. 199. *Idia mandarina* W. Ht ♂ & At ♀ are in Copenhagen Trentepohl Coll (MM, V, 100).

P. 204. *Rhinia testacea* RD. from Mauritius is a synonym of *Idia apicalis* W. from Tenerife. Ht ♂ of *B. glossina* R. is in Genoa (MM, V, 105).

P. 206. *Chlororhinia viridis* TT. is distinct from *exempta* Wlk. latter being a lowland species while former is a highland species. In the key the word "frons" is mistakenly used for frontalia.

P. 208. Gt of *Blæsoxipha* is *laticornis* M. that of *Ravinia* is *striata* F. and that of *Helicobia* is *rapax* Wlk. *Glaucosarcophaga knabi* TT. is wrongly credited to Parker.

P. 225. Species 164 is *Ravinia striata* F.

P. 231. Enderlein's ♂ of *Lioproctia doleschalli* JT, determined by him as *Sarcophaga aurifrons* Dll. has the propleura bare and the midtibiæ thickly long villous, besides possessing 1 PA. Evidently the species here described is distinct in lacking PA and having bare male midtibiæ. Whether it is the same as Doleschall's Ht is not certain. Johnston is twice printed Johnson.

P. 276. Species 211 is *Stephanostoma stephanostoma* Lz. (MM, VI, 70-74).

P. 277. *Sarcophila* R. is synonym of *Agria* RD., Gt *latifrons* Fll. *Leucomyia* is very distinct generically.

P. 279. *Musca affinis* Fll. is Gt of *Pseudosarcophaga*. *Agria hutsoni* SW does not belong to latter genus.

P. 281. *Tachina nuba* W. is evidently a *Disjunctio*. The maggots have been used in surgery! (MM, V, 190).

Practically all the errors and omissions in the volume could have been avoided by consulting the *Annals & Magazine of Natural History*, series 10, VIII, 371-378 (1931) and the *Manual of Myiology*, I, II, V, VI (1934-1938).

CHARLES H. T. TOWNSEND

A PROMISING FUNGOUS PATHOGEN OF ADULT JAPANESE BEETLES (POPILLIA JAPONICA)

The New Jersey Department of Agriculture has actively conducted Japanese beetle suppression work since 1927. During this period opportunity of every description has been available to evaluate the comparative benefits of the weapons of artificial and natural control which are now at our disposal. In a report issued by this Department in 1932, a statement was made that a communicable disease among adults would probably prove to be the most vulnerable channel of Japanese beetle suppression. The control recommendations even as they apply today, consist largely of the use of repellents rather than chemicals which have a destructive effect on the beetle population. The performance of Japanese beetle traps in New Jersey has not been sufficiently convincing to justify the continuation of experimentation on this phase of artificial Japanese beetle suppression.

This Department, in view of its conviction that a communicable disease among adults would make serious inroads in the Japanese beetle population, employed an entomologist for a period of two months during the summer of 1933 and stationed him in the most heavily infested county in the state. His job consisted of examining piles of trapped Japanese beetles, taking samples therefrom and making careful examination of these samples to ascertain the presence of symptoms of bacterial or fungous diseases. These observations did not yield any positive findings. Since 1932 our suppression crews have been instructed to give special attention to the appearance of dead and living adult Japanese beetles with particular reference to the appearance of disease symptoms. To date our field observations have not encountered any such indications of a pathogenic organism being destructive among the adults.

In October, 1939, a list of a local library accessions included a reference to a paper which appeared a few months earlier in the *Canadian Journal of Research*, the title of which was "Pathogenicity of *Beauveria bassiana* (Bals.) Vuill., on Colorado potato

beetle larvæ." The author of this paper, a staff member of the Canadian Department of Agriculture, was the recipient of a letter from this Department requesting a copy of the publication on this subject and also, if possible, a culture of the fungus. Upon the completion of the necessary arrangements with the office of Foreign Plant Quarantines in Washington a permit was procured for the introduction of this culture and it was accordingly sent and received in Trenton November 27, 1939.

According to the individual who supplied this culture this strain of *Beauveria bassiana* is an isolate from cultures made from infected Colorado potato beetle larvæ, discovered in a potato field at Fredericton, New Brunswick, Canada. Its pathogenicity on the larvæ of the Colorado potato beetle has been established.

During December, 1939, and January, 1940, a number of tests were conducted at the White Horse Laboratory of this Department to determine whether or not the Canadian strain of *Beauveria bassiana* was capable of infecting third instar larvæ of the Japanese beetle (*Popillia japonica*). Spores of the fungus were applied dry to some beetle larvæ, while aqueous spore suspensions were applied to other groups of larvæ. A number of beetle larvæ were also confined in tins with soil heavily inoculated with the *Beauveria* spores. The rate of incidence of the fungous disease was very low in these tests, and it was concluded that the fungus probably had little potentiality as a control measure for larvæ of the Japanese beetle.

In July and August, 1940, experimentation was resumed using the adult Japanese beetle, and exposing these to infection by the fungous spores. When the beetles were dusted with the spores a very high rate of infection was obtained, often 100 per cent. Beetles allowed to feed on plant leaves which had been sprayed with a dilute aqueous suspension of the spores were also attacked by the fungus, the rate of infection approximating 75 per cent in a number of tests.

Initially healthy beetles, kept in close association with beetles previously exposed to infection, were found to contract the disease, the rate of incidence varying from 20 to 70 per cent in the initially unexposed beetles.

In a test performed outdoors by spraying food plants of the

beetle with an aqueous spore suspension an indeterminate rate of infection occurred, a number of dead, typically attacked beetles being later found under the sprayed plants. Some beetles removed from the sprayed plants after having been observed to feed, subsequently died of the fungus.

Other beetles, first dusted with the fungous spores, and then placed in outside screened cages began dying in four days, and mortality was practically complete within ten days. Healthy beetles were then introduced into these cages, and later, large numbers of these died, exhibiting the typical external growth of *Beauveria*.

The spores of *Beauveria bassiana* may be produced cheaply and in large quantities upon a variety of culture media. The preliminary tests of infection in adult beetles indicate that the fungus may be a promising new natural control agency for the Japanese beetle.—EDGAR G. REX, New Jersey Department of Agriculture, Trenton, N. J.

BOOK NOTICE

Insect Transmission of Plant Diseases. By Julian Gilbert Leach, Ph.D., Professor of Plant Pathology and Head of the Department of Plant Pathology and Bacteriology, West Virginia University; Formerly Professor of Plant Pathology, University of Minnesota. First edition. 8vo., cloth, 615 pp., 238 illus., McGraw-Hill Publications in the Agricultural Sciences, N. Y., McGraw-Hill Book Co., 1940. \$6.00.

That certain insects have an important part in the spread and development of many plant diseases has become more and more keenly realized during the past two or three decades as constantly increasing evidence has appeared in the literature of plant pathology. Since much of this evidence has been recorded only in widely scattered publications, and has never hitherto been adequately summarized or coordinated, it would appear that there is a definite need for this book. Particularly is this true, since the author has endeavored to bring together in one publication all of the more important contributions in this field of study, and has made special effort to evaluate and interpret the evidence in the light of the more recent advances in entomology and plant pathology. In presenting the material, an effort has been made

to be brief. No attempt has been made to discuss all diseases transmitted by insects or all insects that transmit diseases. Emphasis has been placed on those which have been most thoroughly investigated or which may be best suited to illustrate the various principles of insect transmission. Then too, in discussion of a disease only those facts relevant to insect transmission have been included and much information of general interest in plant pathology has been purposely omitted. In numerous cases, however, suitable references to such information have been given. In like manner, no complete technical descriptions of the insect vectors have been included since information of this kind can be readily obtained from standard entomological texts or from special references cited. In addition to very full and complete introductory matter, the various chapter subdivisions of the book include discussion of such subjects as the interrelationships of plants and insects; symbiosis between insects and microorganisms and its significance in plant pathology; the relation of insects to the spread and development of plant diseases; plant diseases caused by toxicogenic insects; insects and bacterial diseases; insects and fungus diseases; insects and virus diseases; insects and phytopathogenic Protozoa; mites, nematodes, and other small animals as vectors of plant diseases; the anatomy and physiology of plants in relation to infection and insect vectors; the anatomy and physiology of insects in relation to the transmission of plant diseases; the Inocula of plant pathogens in relation to insect transmission; the feeding and breeding habits of insects in relation to the transmission of plant diseases; insect transmission of animal diseases compared with insect transmission of plant diseases; and, methods useful in the study of insect transmission of plant diseases. No general bibliography has been given, but following each chapter there appears a list of references, at times of considerable length, pertaining to its subject matter. All people concerned with plant life, its cultivation and protection will find this book a useful source of information.—J. S. W.

THE TYPE OF THE GENUS PYRRHOPYGE (LEPIDOPTERA—HESPERIIDÆ)

BY W. H. EVANS

There has been a great deal of confusion regarding the type of the genus *Pyrrhopyge* and the identity of certain species of the genus described by Linnæus and other authors. In order to clear up the matter it is necessary to summarize the relevant literature.

(1) Linnæus (1758: Syst. Nat. 10th edition) described on page 485 under the generic group *Papilio Plebeius Urbicola* (= *Hesperiidæ*):

- (a) "*Phidias*. 164. P. P. alis rotundatis atris nitentibus margine albis, ore anoque rubris. M.L.U. Pet Gaz t. 43. f. 15. Habitat in Indiis." The description relates to a black insect with white cilia, palpi and anus red. The figure bears no relation to the description: it is of a moth with a pale apex to the forewing and a broad pale margin to the hindwing.
- (b) "*Bixæ*. 165. P. P. alis rotundatus fuscis, basi virentibus posticis subtus fascia alba. Merian t. 44. Pet Gaz t. 32. f5. Habitat in America." The description is of a dark insect with a white band on the hindwing underside. The Merian figure indicates such an insect, with a red head, palpi and anus: the white band is basal and extends to the end of the cell. The Pet. Gaz. figure depicts an insect with large hyaline spots on the forewing: it does not correspond with the description and represents the insect known as *Epargyreus tityrus* Fab.
- (c) On page 487. "*Acastus* 186. *Papilio Barbarus*. Alis rotundatus albis: maculis quinque transversis apicibusque fuscis: subtus flavescens: In Indiis." The insect is a pierid, which seems to have been overlooked in the "*Lepidopterorum Catalogus*."

(2) Clerck (1759: Icones) published the following figures of insects:

- (a) Plate 42, fig. 4. "*Papilio bixæ*" on the plate, depicting

a well known West African insect with a white band on the hindwing underside, centrally situated, not basally as in the Merian figure, quoted by Linnæus.

- (b) Plate 44, figs. 1. 2. Unnamed on the plate and called "*Papilio phidias*" in the index. It depicts an insect with a very narrow, broken, white band on the hindwing underside: with a red head, palpi and anus.
- (c) Plate 44, figs. 3. 4. Unnamed on the plate or in the index. It depicts an insect with a red margin to the hindwing underside and: it is correctly known as *barcastus* Sepp.
- (3) Linnæus (1764: Mus. Ludovicæ Ulricæ) referred to
 - (a) page 334. No. 152. *phidias*, quoting Clerck plate 44 figs 1. 2. 3. 4. He admits the Pet. Gaz., figure to be a *Phalæna*. He specifies a white band on the hindwing underside, which he says sometimes extends to the upperwing: he adds that the female has a red edge (*barcastus*). It will be seen that he had departed from his original description and has included three other species under the name *phidias*.
 - (b) page 335. No. 153. *bixæ*, quoting Clerck plate 42 fig. 4 as well as Merian plate 44. He adds that the Pet. Gaz. figure he previously quoted is of an insect from Carolina with hyaline spots on the forewing and a white band on the hindwing underside (*tityrus*).
- (4) Linnæus (1767: Syst. Nat. 12th edition 1/2: page 795 made the following additions to the 10th edition.
 - "*Phidias*. 263. Mus. Lud. Ulr. 334. Clerck ic. t. 44. f. 1. 2. 3. 4. *Bixæ*. 264. Mus. Lud. Ulr. 335. Clerck ic. t. 42. f. 4."
- (5) Cramer (Pap. Exot.) described and figured the following:
 - (a) 1775. Vol. I. plate 41, C.D. *Papilio* P. U. *acastus* Nov: Surinam. An insect with a yellow edge to the hindwing underside. His name falls as a homonym of *acastus* Linnæus, see (1) above and the correct name is *venezuelæ* Scudder.
 - (b) 1779. Vol. III, plate 199, C.D. *Papilio* P. U. *bixæ* Linn: Guiana. The white band on the hindwing underside extends to the upperwing and represents a different insect to

that figured by Merian or figured by Clerck: it was named *fluminis* by Butler in 1872.

- (c) 1779. Vol. III, plate 199, E. *Papilio* P. U. *acastus* Cramer: Surinam. An insect with a red edge to the hindwing underside: it is *barcastus* Sepp.

- (d) 1779. Vol. III, plate 244 A.B. *Papilio* P. U. *phidias* Linn: China, Bengal and Surinam. It is not any of the insects called *phidias* by Linnæus, but the very different *Pyrrhocalcia iphis* Drury.

- (6) Fabricius (1793: Ent. Syst. 3: pages 344 to 347) includes:

- (a) *bixæ* Lin: considered to be a variety of *tityrus* Fab.

- (b) *zeleucus* Nov: black with white cilia, head and anus red: "Indiis"; figured in Jones icones (unpublished), vol. 6, plate 25, fig. 2. It is the true *phidias* Lin., which he misidentified.

- (c) *mænas* Fab. 1787: black with white cilia, palpi and anus red, a white band on the hindwing underside: in America: Mus. Dr. Hunter. It is the true *bixæ* Lin., which he misidentified.

- (d) *phidias* Lin: placed as being synonymous with *acastus* Cram.

(7) Donovan (1800: Insects of India etc.) figured *zeleucus* Fab. on plate 51, fig. 3, corresponding with Fabricius' description, excepting that the legs are dark red.

(8) Hübner (1819: Verzeichniss: 103) introduced the genus *Pyrrhopyge* for:

1077. *bixæ* Linn: Syst. Pap. 264. Cramer 199 C. D.

1078. *hyperici* Hübner: not described till 1823 (Zuträge 2: 16).

1079. *phidias* Linn: Syst. Pap. 263. *acastus* Cramer 41 C, D and 199, E.

1080. *amyclas* Cramer: 199, E. 1081. *arinas* Cramer: 100, D.

(9) Swainson (1820: Zool. Ill. 1/1: plate 33) figures *zeleucus* Fab. assigning a new generic name *Tamyrius*: the figure corresponds with Fabricius' description and the figure in Jones Icones, with black and not the red legs of Donovan's figure.

(10) Latreille (1824: Enc. Meth. 9: 732-740) includes under *Hesperia*:

zeleucus Fab., with *thasus* Cramer (quite a distinct species) as a synonym.

phidias Lin.: with *acastus* Cramer as a synonym.

bixæ Lin.: with the white band on the hindwing underside as basal and not central as in Clerck's figure.

acastus Fab.: with *apastus* Cramer and various other quite distinct species as synonyms.

(11) Doubleday and Westwood (1852: Diurn Lep. II: 509 and 515) included:

Pyrrhopyga thasus Cram. = *zeleucus* Fab.

mænas Fab. = *bixæ* Cram.

phidias Lin. = *acastus* Cram. 199 and 41.

Ismene chalybe Nov. = *bixæ* Lin.?, but not the *bixæ* of Merian plate 44.

(12) Wallengren (1858: Kon. Vet. Akad. Forh. 15: 2) introduced the generic name *Pachyrhopala* for *phidias* Lin.

(13) Felder (1867: Reise Novara Zool. 2) uses the generic name *Tamyris* and not *Pyrrhopyge*.

(14) Herrich Schäffer (1869: Corr.-Blatt. Regensburg 23: 164-166) in his Prodomus included under *Pyrrhopyga*:

zeleucus Swainson (unmarked on hindwing underside).

bixæ Cramer (white band on hindwing underside).

acastus Cramer (yellow edge on hindwing underside): 41 C.

phidias Lin. (red edge on hindwing underside).

mænas Fab.: unknown to him.

(15) Scudder (1872: Fourth A. R. Peabody Acad. Sci.: 167) listed the genus thus:

Pyrrhopyga Hübner.

Type *Papilio bixæ* Linnaeus.

1. *affinis* HS. 2. *venezuelæ* Nov. 3. *chalybea* Nov.

(16) Butler (1872: Cist. Ent. 1: 176) realizing that *bixæ* Cramer was a different species from *bixæ* Lin., renamed the former *fluminis*.

(17) Scudder (1875: Proc. Amer. Acad. Arts & Sci., Boston, 10: 261) substituted *hyperici* Hübner as the type of *Pyrrhopyge*, on the ground that *phidias* (*bixæ*) had already been taken as the type of *Pachyrhopala* Wallengren, which genus was a synonym of *Tamyris* Swainson, type *zeleucus* Fab.

(18) Mabille (1878: Ent. Belg. 21: 13). Gen. Insectorum 1903. *Pyrrhopyginae* revision with Boulet 1908: An. Sci. Nat. 9/7) came to the following conclusions:

- (a) *Pyrrhopyge bixæ* Cram nec Linnæus.
- (b) *Pyrrhopyge phidias* Lin.: Clerck's plate 44, figs. 1. 2.: = *mænas* Fab.
- (c) *Pyrrhopyge zealeucus* Fab.: on Donovan's figure assigned a red pectus, an entirely different species to the true *zealeucus*.
- (d) *Mysoria venezuela* Scudder, *acastus* Cramer and *barcastus* Sepp. (= *phidias* Fab.) as three separate species.
- (e) *Rhopalocampta bixæ* Lin. from W. Africa.

(19) Plötz (1879: Stett. Ent. Zeit. 40: 179, 533, 535. 1884: Id 45: 65) dealt with the various species as follows:

- (a) *Pyrrhopyge phidias* Lin. = *mænas* Fab. and *bixæ* HS.
- (b) *Pyrrhopyge fluminis* Butler = *bixæ* Cramer.
- (c) *Pyrrhopyge zealeucus* Fab.: as described by Fab.
- (d) *Pyrrhopyge barcastus* Sepp. = *phidias* Clerck plate 44, figs. 3. 4.
- (e) *Pyrrhopyge acastus* Cramer 41 C, D = *phidias* Lin. 1764.
- (f) *Ismene bixæ* Lin.: W. Africa.

(20) Aurivillius (1882: Kong Svenska Vet.—Ak. Handl. 19/5: 61, 121, 123) in his analysis of the species described by Linnæus.

- (a) *acastus* Lin. is probably a Pierid.
- (b) *phidias* Lin. is the species figured by Clerck on plate 44, fig. 1. 2.
- (c) *bixæ* Lin. is to be taken as figured by Clerck on plate 42, fig. 4 and Merian's figure refers to *phidias*.

(21) Watson (1893: PZS: 11) follows Scudder (1875 not 1872) in taking *hyperici* Hübner as the type of *Pyrrhopyge*. He places *bixæ* Lin. in the genus *Rhopalocampta* Wallengren and erects the genus *Mysoria* with *acastus* Cramer as the type.

(22) Godman and Salvin (1893: Biol. Centr. Amer. Rhop. 2: 246, 247) considered *hyperici* to be the type of *Pyrrhopyge*; they follow Aurivillius regarding *phidias* Lin. and Mabille regarding *zealeucus* Fab.

(23) Seitz (1921: Macrolepidoptera) follows Aurivillius regarding *phidias* and *bixæ* Lin.; Mabille regarding *zealeucus* Fab.,

gives *bixæ* Cramer (= *mænas* Fab.) as a separate species and treats *acastus* Cramer and *venezuelæ* Scudder as separate subspecies.

(24) Lindsey (1925: Ann. Ent. Soc. Amer. 18: 99) asserts that Scudder's first type selection must be regarded as valid, i.e., *bixæ* Lin.: he adds that *bixæ* and *hyperici* are congeneric.

(25) Bell (1931: Jour. N. Y. Ent. Soc. 39: 420, et seq. 1933: Id 41: 268) deals with the genera and species as follows:

- (a) *Pyrrhopyge* type *hyperici* Hübner.
- (b) *zeleucus* Fab.: cannot recognise.
- (c) *phidias* Lin. = *mænas* Fab.: with a narrower white band on hindwing underside.
- (d) *fluminis* Butler = *bixæ* Cramer, nec Linnæus, which is an African species.
- (e) *Mysoria pallens* Mab. = *acastus* Cramer a homonym of *acastus* Lin.: *pallens* is a subspecies of *venezuelæ* Scud.

In accordance with the International Rules for Zoological nomenclature *bixæ* Lin. must be taken as the type of *Pyrrhopyge*. In any case *hyperici* Hübner cannot be used, as that species had not been described at the time that *Pyrrhopyge* was introduced. If Aurivillius' determination of the identity of *bixæ* Lin. is correct, it follows then that the generic name *Pyrrhopyge* must be used in replacement of the name *Cæliades* Hübner (= *Rhopalocampta* Wallengren). *Tamyris* Swainson type *zeleucus* Fab. would have to be used for the American species usually included under *Pyrrhopyge*.

The identity of any scientific name, such as *bixæ*, must, however, be considered in respect of the original description: qualifications subsequently published can only be regarded as an aid to the elucidation of the author's original intention and must be rejected if they conflict therewith. The description given by Linnæus in 1758 agrees with the Merian figure and not with the Pettifer figure he quotes: so the Merian figure must be taken as representing the type of *bixæ* Lin. The Clerek figure represents an entirely different insect from W. Africa, which Linnæus in 1764 quite incorrectly considered to be conspecific with the insect figured by Merian. Aurivillius' determination must therefore be rejected.

Bell (see No. 25 above) in his comprehensive revision of the

genus *Pyrrhopyge* brought to light that there was more than one species exactly resembling *bixæ* Linn., as here determined, but differing markedly in the genitalia. It is considered that the name should be applied to the species, which is in the B.M. from Surinam, the type locality, with genitalia as figured by Bell for *Pyrrhopyge latifasciata* Butler (1931: Jour. N. Y. Ent. Soc. 39: 485). Actually *latifasciata* is a form with a wider white band on the hindwing underside: in *bixæ* the band extends to the end of the cell but not beyond. *Mænas* Fab. is considered to be a synonym of *bixæ* Lin.

A new name is required for *bixæ* Clerck nec Lin. and *Cæliades bixana* Nov. is hereby assigned: it is sufficiently defined by Evans (1937: Cat. Afric. Hesp.: 11) and a male specimen in the British Museum from the Gold Coast has been marked as the holotype.

The identity of *phidias* Lin. must also be considered in respect of the original description. The Pettifer figure must be rejected as not agreeing with the description. The Clerck figures subsequently quoted by Linnæus must also be rejected: the original description makes no mention of either the white basal band of *phidias* Clerck or of the yellow edge of the second set of figures. The figure given by Cramer does not agree with Linnaeus' description. The description of *zeleucus* Fab. and the figure thereof in Jones' Icones does agree with the original description of *phidias* Lin. It is considered therefore that *zeleucus* Fab. should be regarded as a synonym of *phidias* Lin. Here again Bell has shown that there is more than one species exactly similar to *phidias* Lin., as here determined, but differing markedly in the genitalia. It is considered that the name should be applied to the species described by Bell as *Pyrrhopyge williamsi* (1931: Jour. N. Y. Ent. Soc. 39: 430). As pointed out above (No. 18) Mabille was incorrect in his determination of *zeleucus* Fab.

Bell (see No. 25 above) is quite correct in his action regarding *acastus* Cramer: the name must be abandoned as a homonym. It is considered that the oldest name for the collective species is *Mysoria barcastus* Sepp. of which *barcastus* Sepp (= *acastus* Cramer 1779 and *verbena* Butler), *pallens* Mabille (= *acastus* Cramer 1775) and *venezuelæ* Scudder are forms or subspecies.

A NEW BRENTHIS FROM ALASKA (LEPIDOPTERA, NYMPHALIDÆ)

BY ALEXANDER B. KLOTS

COLLEGE OF THE CITY OF NEW YORK

Brenthis (Clossiana) aphirape denali, new subspecies.

While the writer feels a certain hesitation at adding another subspecific name in *aphirape* to the already rather long list, the form named here is so utterly distinct from any other members of the species that there is no doubt of its validity. From other subspecies of *aphirape* in North America, *denali* may be differentiated as follows:

MALE—Upper side: Ground-color pale yellow-brown, the black markings fine and clear-cut. The ground-color is lighter than that of any other *aphirape* subspecies except *laddi* Klots (Snowy Range, Wyo.) and *caelestis* Hemming (Colorado). In the fineness and sharpness of the black markings *denali* likewise resembles *laddi* and *caelestis* most closely, for the other North American subspecies all have heavier markings with considerable suffusion, as well as a deeper orange-brown or red-brown ground-color. In the basal and anal regions of the hind wings *denali* has slightly more fuscous dusting, and is more hairy, than *laddi* and *caelestis*.

FEMALE—Upper side: The ground-color is somewhat duller and the black markings heavier and more suffused than in the males. Compared with females of other North American subspecies, *denali* females average paler with lighter markings and less fuscous suffusion than those of any subspecies other than *laddi* and *caelestis*; their marking are slightly more suffused, and the basal dusting of the hind wings more extensive, than in these two latter.

BOTH SEXES—Under side: The fuscous or black markings, repeated from the pattern of the upper side, are slightly heavier in the females than in the males. In other respects the females show no essential differences from the males. In both sexes the fuscous or black markings are more reduced than in any other North American subspecies, including *laddi* and *caelestis*.

The ground color is much paler than in any other North American subspecies, having a very "washed out" appearance. On the hind wings the post-basal and median rows of darker spots are of a light, yellow-brown color, much lighter than in any other North American subspecies except *caelestis*. The submarginal area which, in all other North American subspecies is largely filled in with dark orange-brown or red-brown in cells R_1 , R_5 , M_1 , Cu_1 , and Cu_2 , at least outwardly, is in *denali* almost entirely of the very light, yellowish ground-color with only a slight brownish tinge in the costo-distal corner of cell R_1 . The row of round, ocellate spots in this submarginal area is very much obscured, being almost entirely faded out in some specimens. The marginal and the irregular sub-median rows of light-colored spots are of a pale, yellowish-white with only an occasional trace of pearly luster.

Denali is almost the most distinct subspecies of *aphirape* in North America, the extremely pale, "washed out" appearance of the under side of the wings sufficing for its recognition at a glance. Of the 43 specimens of the type lot, only two show sufficient dark coloring beneath to be in any way confusable with any other North American subspecies; and the resemblance of these is to *caelestis*, the Colorado subspecies, rather than to *nichollae* or *triclaris*, the closest subspecies geographically.

Two specimens from Atlin, B. C., are intermediate between *denali* and *nichollae*. They are not to be considered as representative *denali*, or as part of the type lot.

Leussler's reference (Bull. Brooklyn Ent. Soc., 1935, 30: 52) to a male and a female of *aphirape* from the Mackenzie Delta under the name of *alticola* Barnes & McDunnough (a homonym, = *caelestis* Hemming) is inadmissible, as pointed out by the present writer (Journ. N. Y. Ent. Soc., 1937, 45: 325). The pale coloration which led Leussler to use the name *alticola* for these specimens is here seen to be characteristic of *denali*. It is therefore quite probable that the Mackenzie Delta specimens should be referred to *denali* or, at least, that they represent a transitional population between *denali* and *triclaris*.

The name of this new subspecies is the Indian name for Mount McKinley.

Types: Holotype ♂, July 25, 1931, and allotype ♀, July, 1931, McKinley National Park, coll. by Frank Morand, ex Gunder Collection.

Paratypes: 21 ♂, the same locality and collector, July, 1931; 1 ♂, the same locality and collector, 24 July, 1931; 1 ♂, the same locality and collector, 25 July, 1931; 1 ♂, the same locality and collector, 28 July, 1931; 4 ♀♀, the same locality and collector, July, 1931; 1 ♀, the same locality and collector, 24 July, 1931; 3 ♂♂ and 1 ♀, the same locality, coll. by G. P. Engelhart, 3500 ft. altitude, 5 July, 1938; 1 ♂ and 1 ♀, the same locality, coll. by D. Fraser, 29 July, 1930; 1 ♂, Cantwell (S. of Fairbanks) Alaska, coll. by D. G. Nicholls, 14 July, 1937; 3 ♂♂ and 1 ♀, Alfred Creek Camp, Alaska, coll. by R. A. Pope, 15 July, 1922; 1 ♂, Alfred Creek Camp, Alaska, coll. by R. A. Pope, 21 July, 1922.

The holotype, the allotype and most of the paratypes are in the American Museum of Natural History. Paratypes are in the collections of Cyril dos Passos and the author.

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